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THREE ESSAYS ON CO-MANAGEMENT IN A FISHERY

BY

MIHOKO TEGAWA

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS

UNIVERSITY OF RHODE ISLAND

2015

DOCTOR OF PHILOSOPHY DISSERTATION
OF
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2015

ABSTRACT

Co-management has been recognized as an important scheme in successfully governing common-pool resources (Ostrom, 1990, 2002). Contrary to Hardin's Tragedy of the Commons (1968) or Olson's Logic of Collective Action (1965), empirical research has found many long-lasting self-governing communities through extensive case studies (Baland & Platteau, 1996; Ostrom, 1990; Wade, 1989). This is no exception in fishery (Pinkerton, 1994). Fishery cooperatives, where fishermen collectively manage the fishery, have been garnering much attention from both regulators and academics (Costello, 2012; Deacon, 2012; Townsend, Shotton, & Uchida, 2008). In fact, Northeast multispecies groundfish fishery in US has implemented a sector management system, in which voluntarily formed sub-groups of harvesters may manage their collective total share of the harvest as a group right (Pinto da Silva & Kitts, 2006). Thus, understanding how and why fishery co-management succeeds is not only important but also timely in terms of policy relevance.

The overarching goal of this dissertation is to investigate how co-management in a fishery can contribute to better societal outcomes. To meet this goal, I construct the following two objectives and the hypotheses associated with each objective. The first objective corresponds to manuscript 1, and the second objective spans over manuscripts 2 and 3.

The first objective is to examine how common property management systems may emerge endogenously. In particular, recent trends in fisheries management are to further devolve responsibility to users by partitioning allowable extraction and

assigning them to groups of users. Each group may manage their collective share of the harvest of each species as a group right, which results in a fishery with a single set of total allowable catch concurrently managed by multiple management groups. I designed a laboratory experiment based on the Rhode Island Fluke Sector Pilot Program, which features a sector managed by individual quota and a common pool derby for harvesters who do not join the sector. I allowed harvesters to choose whether to join the individual quota sector prior to each season based on the outcomes they experience under each system. The main hypothesis is that subjects move toward the individual quota system, which supports the efficient harvesting strategy as equilibrium, rather than adopt cooperative strategies in a less restrictive common pool institution, or stay in an inefficiently operating common pool. I then associate individual variation in the rate of moving to the individual quota system with other-regarding preferences, risk preferences, and a taste for competition.

Through successive fishing seasons, the frequency of subjects' choosing the individual quota sector rises from half to over 80 percent of subjects. This suggests that the efficiencies associated with strong individual fishing rights may emerge endogenously from the sectorization process, even without imposing them through regulation. The results also find enjoyment of competition becomes significant at later seasons, but other-regarding preferences and risk preferences are not a significant driver in the long run.

The second objective is to explain why and how revenue sharing arrangement in a co-managed fishery can achieve successful management and to provide insights into revenue sharing arrangement as an alternative management tool. Under revenue

sharing arrangement a group of harvesters shares catch and/or revenue among members of a fishery cooperative equally, or according to an agreed rule, regardless of individual effort or performance. Social capital potentially affects the efficiency that revenue sharing brings while revenue sharing can foster social capital, which could eventually lead to better management outcomes. I hypothesize the synergy between the two factors, i.e., revenue sharing arrangement and social capital. An important intermediary between the two factors and the outcomes is collective efforts performed as a group often in a community-managed fishery. The following four hypotheses will be tested under this objective. First, the fishery groups under revenue sharing arrangement achieve better outcomes in a fishery, compared with similar groups without such arrangement. Second, the fishery groups with greater social capital achieve better outcomes in a fishery. Third, the interaction between revenue sharing arrangement and social capital further enhances success in a fishery. Lastly, the groups under revenue sharing arrangement foster greater social capital.

I quantified social capital using controlled economic experiments with fisherman subjects as well as surveys. Using the data collected from ten fishery groups engaging in a small-scale trawl fishery in northern Japan and wild cluster bootstrap for small sample inference, I find the indirect effect of revenue sharing augmenting information network, which then improves an economic outcome in a fishery. Revenue sharing arrangement provides disincentives to compete and accompanies synchronized collective fishing operation, which encourages fishers to exchange sensitive fishing information that would not have been shared otherwise. This greater information network then has a positive impact on economic performance because it enables

fishery groups to effectively coordinate in fishing efforts and other collective efforts. However, the direct effect of revenue sharing improving an outcome does not seem to be robust. In addition, I find evidence of various aspects of social capital improving both outcomes in a fishery. While trust increases the ex-vessel prices, the groups with fishers having similar information network size achieve better stock conditions over time. Interestingly, revenue sharing fishers are no more likely to cooperate unconditionally (i.e., unilaterally) and furthermore they are less likely to cooperate conditionally (i.e., only if others cooperate).

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PREFACE

Manuscript Format is in use for this dissertation. The dissertation consists of three manuscripts along with overarching introduction and conclusion.

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INTRODUCTION

Direct regulation, or so-called command-and-control, has been a standard management tool for regulators in balancing the conservation of coastal resources and achieving economic efficiency of resource use. However, direct regulations are often ineffective in achieving these goals. This is in part due to the fact that for regulations to meet both environmental and economic goals in fishery they need to have an extensive knowledge on the resources and fishers' harvesting activities. It is apparent that this is often not the case.

First suggested by Christy (1973), an individual quota or a catch shares system has been recognized as an effective alternative to direct regulations for better fishery management (Arnason, 1990), but not without limitations. While often dubbed as decentralized or privatized system so as to suggest that it needs minimal involvement of governments, the catch share system requires governments with strong enforcement powers and well-established market institutions. For example, without an effective monitoring and enforcement of allocated share (i.e., making sure that no one exceeds the share) the catch share system will be undermined and could eventually collapse (Copes, 1986). If a share is transferable, market institutions are necessary to ensure transactions and to set the market price that reflects the shadow value of the fishery.

Co-management has been gaining attention in fishery management in the US. For example, the Northeast multispecies groundfish fishery implemented a sector management system (Amendment 16), in which voluntarily formed sub-groups of harvesters may manage their collective total share of the harvest of each species as a group right. Fishery cooperatives, where fishermen collectively manage the fishery,

have been garnering much attention as a way to complement and/or supplement existing management systems such as rights-based management from both regulators and academics (Deacon, 2012; Townsend, Shotton, & Uchida, 2008). Thus, understanding how and why the fishery co-management succeeds is not only important but also timely in terms of policy relevance.

Co-management is a broad concept that its precise definition can hardly be complete. It can be agreed, however, that co-management represents a “collaborative and participatory process” of decision-making as regards to management of one or more natural resources among or between multiple stakeholders such as user-groups and government agencies (Wilson, Nielsen, & Degnbol, 2003, p. 3). In this dissertation the essential aspect of co-management is that resource users possess independent regulatory power to set and enforce their own rules of management under the authorities. Thus, it is not exclusive to non rights-based management or other types of rights-based management. In the case of fisheries management co-managed fisheries can self-implement the individual quota system, transferable or not, in addition to other operational and management rules.

The overarching goal of this dissertation is to investigate how co-management in a fishery can contribute to better societal outcomes. To meet this goal, I construct the two objectives and the hypotheses associated with each objective (Figure A).

While regulators rarely implement a new system to manage natural resources without facing any opposition, resource users’ voluntary transition to an efficient management system, if possible, can ease such political hindrance. All regulators need to do is to let a community decide what is best for them. In fact, sector management in

Multispecies Groundfish Fishery in Northeast US has allowed harvesters to essentially decide how to manage an allocated share of the catch. As a result, the fishery has been experiencing the transition to a catch shares system since 2010 although some doubts on to what degree a decision was voluntary during later years have been expressed (Olson and Pinto da Silva, 2014). Furthermore, voluntary transition to a more efficient management of the resources can eventually bring harvesters' awareness of co-management because the transition may signal the importance of engaging in management decisions as a community.

The first objective in this dissertation, addressed in the first manuscript, is to examine how common property management systems can evolve endogenously. In particular, recent trends in fisheries management are to further devolve responsibility to users by partitioning allowable extraction and assigning them to groups of users. Each group may manage their collective share of the harvest of each species as a group right, which results in a fishery with a single set of Total Allowable Catch (TAC) concurrently managed by multiple management groups. I designed a controlled economic experiment based on the Rhode Island Fluke Sector Pilot Program (Anderson & Uchida, 2014; Georges Bank Cod Fixed Gear Sector, 2010; Pinto da Silva & Kitts, 2006; Verani, 2006), featuring a sector managed by individual quota and a common pool derby for harvesters who do not join the sector. I allowed harvesters to choose whether to join the individual quota sector before each season based on the outcomes they experience under each system. The main hypothesis is that subjects move toward the individual quota system, which supports the efficient harvesting strategy as equilibrium, rather than adopt cooperative strategies in a less

restrictive common pool institution, or stay in an inefficiently operating common pool (H1). I then associate individual variation in the rate of moving to the individual quota system with social preferences, risk preferences, and a taste for competition.

Revenue sharing arrangement is a type of co-management practice, in which harvesters share catch and/or profits among the members of a fishery cooperative. Employment of such arrangement is a collective action that a group of harvesters takes. The role of revenue sharing arrangement in fishery co-management has been studied in the literature (Gaspart & Seki, 2003; Platteau & Seki, 2001; Uchida & Baba, 2008), but less studied are the quantitative effect of revenue sharing on management outcomes (H2a) and its mechanism, through which revenue sharing arrangement attains success. In manuscripts 2 and 3 I hypothesize that the interaction between revenue sharing and social capital exists; revenue sharing affects social capital in a community and among fishers, and social capital also influences various incentives possibly induced under revenue sharing and the efficiency that such arrangement brings (H2c).

Social capital is a concept that the attributes such as trust, cooperation, and reciprocity among people and norms and networks in a community are important in improving economic life (Fukuyama, 1996; Putnam, 2001). In particular, the role of social capital in a community that self-governs a community resource has been highlighted (Ahn & Ostrom, 2008; Bowles & Gintis, 2002; Gutiérrez, Hilborn, & Defeo, 2011; Pretty, 2003). In fact, Carpenter and Seki (2011) showed a strong correlation between fishermen's propensity to cooperate and fishing productivity. Social capital is also found to be empirically associated with economic productivity in

other workplace (Barr & Serneels, 2009; Bouma, Bulte, & van Soest, 2008; Carter & Castillo, 2002; Karlan, 2005; Knack & Keefer, 1997).

The objective consisting of the manuscripts 2 and 3 is to explain why and how revenue sharing arrangement can achieve successful management of a fishery. The manuscript 2 provides the first rigorous analysis on measuring the direct effects of revenue sharing (H2a) and social capital (H2b) in a community-managed fishery, and to identify the indirect effects resulting from the interaction between revenue sharing and social capital (H2c). An important intermediary between the two factors, revenue sharing arrangement and social capital, and the outcomes of a fishery is collective efforts defined as any efforts performed as a group to increase harvesting performance of a fishery. The efforts include stock enhancement, rotation of fishing grounds, collective search for schools of fish, and collective use of fishing boats and/or fishing gear. Revenue sharing arrangement and social capital enhance the effect of the collective efforts, which leads to efficient and sustainable use of resources in the long run. Contribution to the group efforts aligns with self-interest when a group of harvesters shares revenue and harvesters are devoted to collective value due to social capital in a community.

The manuscript 3 provides the quantitative effect of management systems—whether the group has employed revenue sharing or not—on the social aspect of a community (social capital). In particular, this manuscript asks whether a difference in management systems can result in different cooperative relationships and different information networks in a community (H3). This manuscript provides the first rigorous analysis to measure the effect of different management systems on social

capital and provides insights into an effective policy that can be employed for development of social capital.

I empirically test the hypotheses in the manuscripts 2 and 3 using the data collected in Japan, which is one of the countries that have a long history of co-management in a fishery (Yamamoto, 1995) as well as ample cases of revenue sharing. Many Japanese fisheries operating under revenue sharing have been successfully managing the resources as well as generating resource rents (Carpenter & Seki, 2011; Platteau & Seki, 2001; Uchida & Baba, 2008). I collected this unique dataset containing group information from ten fishery groups engaging in small-scale trawl fishery and individual information on 79 skippers belonging to the ten groups. To quantify cooperation controlled economic experiments with fisherman subjects were conducted. As for trust and information network indices are constructed from survey responses of the same fisherman subjects. For the manuscript 2, I collected four measurements of the outcomes in a fishery: ex-vessel price per kilogram (economic outcome), resource stock density measured per squared meter (biological outcome), and the other two from the survey (economic success perceived by fishers and resource conditions perceived by fishers). Using wild cluster bootstrap for small sample inference of the ten fishery groups, I rigorously quantify the effect of revenue sharing and social capital. In addition, I explore the mechanism, through which those factors interact with each other and affect the outcomes in a fishery.

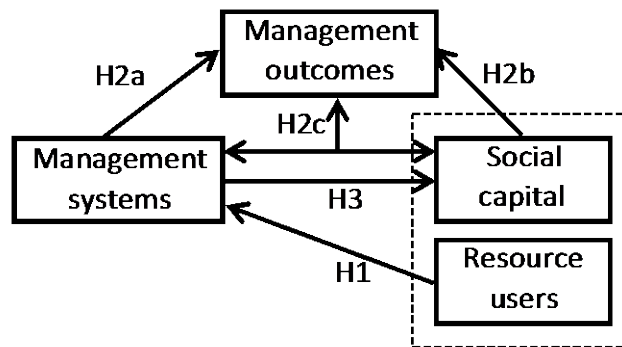
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Figure A. Conceptual Framework



MANUSCRIPT – 1

The Endogenous Evolution of Common Property Management Systems

In preparation for journal submission

by

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The Endogenous Evolution of Common Property Management Systems

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Abstract

While management of common pool resources has long recognized the value of including resource users in the governance process, recent trends in fisheries management are further devolving responsibility to users by partitioning allowable extraction and assigning them to groups of users. Each group may manage their collective share of the harvest of each species as a group right, which results in a fishery with a single set of total allowable catch concurrently managed by multiple management groups. This paper investigates how individual and aggregate outcomes emerge as groups gain experience with use of their collective rights. We designed a laboratory experiment, which features a sector managed by individual quota and a common pool derby for harvesters who do not join the sector. We allowed harvesters to choose whether to join the individual quota sector before each season based on the outcomes they experience under each system. Through successive fishing seasons, the frequency of subjects' choosing the individual quota sector rises from half to over 85 percent of subjects. This suggests that the efficiencies associated with strong individual fishing rights may emerge endogenously from the sectorization process, even without imposing them through regulation. Interestingly, a taste for competition prohibits a complete transition into the individual quota sector.

1.1 Introduction

While management of common pool resources has long recognized the value of including resource users in the governance process (McCay & Acheson, 1987; Ostrom, 1990; Ostrom et al., 1999), recent trends in fisheries management are further devolving responsibility to users by partitioning allowable extraction and assigning them to groups of users. These “use share” programs involve users not to determine a single set of use rules, but rather encourage the formation of sectors—groups allocated a collective share of total extraction that they may manage in any way they wish. Different groups may manage their extraction in different ways while pursuing the same resource, which integrates heterogeneity in management system preferences as an intentional element of regulation. Sector management has emerged as progressive user groups within large, heterogeneous fisheries; these fisheries has coalesced to implement a particular management innovation, but without establishing the political consensus for management change among all harvesters. This mitigates the task of managers persuading all participants to use the same system, facilitating political progress. However, it requires a framework for predicting outcomes when different sectors must strategically interact with one-another (Anderson & Uchida, 2014; Scheld, Anderson, & Uchida, 2012).

A mechanism anticipating that groups will affiliate and manage themselves differently became an explicit element of federal management of fisheries.

Amendment 16 of the Northeast Multispecies Management Plan associates a historical catch level of each regulated species with each harvester, assigns the quota to the sector joined by the harvester, and allows the sector to manage; harvesters who do not

join a sector operate in a common pool under legacy days-at-sea regulation. In early applications, a group of harvesters petitioned management for an allocation of a share of the Total Allowable Catch (TAC) to manage internally, with more flexibility than harvesters who continue under legacy management (Georges Bank Cod Fixed Gear Sector, 2010; Pinto da Silva & Kitts, 2006; Scheld, Anderson, & Uchida, 2012; Verani, 2006). The first year saw 17 sectors form, mostly using some form of Individual Transferable Quota (ITQ), along with the common pool (Northeast Fishery Science Center (NEFSC), 2011). However, even where ITQ systems—expected by economists to maximize returns—are implemented directly, collective management often emerges. On the West Coast US, the groundfish fishery implemented a standard ITQ program, and participants responded by developing collective management systems and risk pools to manage limiting species that closely resemble cooperatives reviewed in the self-governance literature (Holland & Jannot, 2012).

Similarly, a mixture of different management systems governing the same resource stock can be observed in other types of common pool resources. Forest ejidos in Mexico resulted in a mixture of different stages of privatization of forest nationwide after the federal government passed the law to allow resource users to convert some plots of common property forest into private forest (Barnes, 2009; Barsimantov et al., 2010). From groundwater in California to forest in the Himalayan ranges groups of resource users adopt management systems suiting the community's own needs and preference where possible, creating heterogeneity in management institutions (Agrawal, 1994; Blomquist, 1992, 1994; Trawick, 2001).

These cases suggest that, while ITQ systems are thought by economists to

work through the market to produce efficient outcomes, these systems continue to evolve institutionally after transferable rights are established, and that competitive markets of arm's length transactions are often a relatively small component of the management institution that prevails. This raises the question of what properties the emergent management systems will have. As catch share programs expand, what predictions can be made about how self-management will evolve, to support biological and social evaluation mandated through the Environmental Impact Analysis process? Will they take a consistent form? Or, will they take different forms that result in improvements in efficiency? Will they be Pareto safe? What sorts of rules for migrating among sectors facilitate the greatest improvements in efficiency most quickly?

Theoretical guidance on these questions is scarce, largely because regulatory processes around the world have focused on trying to implement final structures, which are restricted to evolve only in very limited ways after they are implemented. Economic theory generally predicts that rights holders will gravitate toward institutions with incentives that support efficiency as an equilibrium (Gürerk, Irlenbusch, & Rockenbach, 2006). An alternative set of hypotheses emerges from the self-governance literature, which offers reasons that users might establish cooperative institutions (Agrawal, 2002). These cooperative institutions can be efficiency enhancing even in the absence of individual incentives to do so. While both models predict efficiency, the resulting institutions differ importantly in attainability, distributional consequences, or robustness to resource shocks.

To begin developing a framework to address these questions, we designed a

controlled economic experiment based on the Rhode Island Fluke Sector Pilot Program (Anderson & Uchida, 2014; Georges Bank Cod Fixed Gear Sector, 2010; Knapp, 2008; Pinto da Silva & Kitts, 2006; Scheld, Anderson, & Uchida, 2012; Verani, 2006), featuring a sector managed by individual quota, and a common pool derby for harvesters who do not join the sector. We allowed harvesters to choose whether to join the individual quota sector before each season based on the outcomes they experience under each system. We test the hypothesis that subjects move toward the individual quota system, which supports the efficient harvesting strategy as equilibrium, rather than adopt cooperative strategies in a less restrictive common pool institution, or stay in an inefficiently operating common pool. We then associate individual variation in the rate of moving to the individual quota system with social preferences, risk preferences, and a taste for competition.

1.2 Experimental design

Continuous Fishing Game

A two-stage sequential game is repeated for 20 “seasons”, in each of nine experimental sessions with twelve inexperienced subjects each. In the first stage, all subjects simultaneously choose to affiliate with either an individual quota (IQ) group—where each subject receives their quota share as an individual allocation—or a common pool (CP) managed group—where the quota associated with each subject is placed in a shared pool to be used be accessed by all subjects choosing CP. In the second stage, players learn how many others are in each group and then earn money fishing under the rules of their chosen management group.

The fishing subgame is a quasi-continuous common-pool resource game with a contemporaneous price externality, developed by Anderson and Uchida (2014) based on Walker et al. (1990) and Gardner et al. (1997). The setup is as follows. Consider a common-pool resource appropriated by $i = 1, \dots, N$ players. Each player i chooses effort level e and maximizes the following payoff function regardless of choice of management systems in the first stage:

$$\pi_i = \frac{e_i}{E} h(E) [\alpha - \beta h(E)] - c(e_i)$$

where $h(\cdot)$ is a concave production function, $c(\cdot)$ is a linear cost function, and $E = \sum_{i=1}^N e_i$. The unit price is determined by the term $\alpha - \beta h(E)$, which decreases in total landings from all players regardless of management systems. Thus, players can maximize their profits by fishing in weeks when the total landings are lower.

Assuming identical players and replacing E with $n\bar{e}$, the first-order condition is:

$$\frac{1}{N} \left[\frac{dh(\cdot)}{de} P(N\bar{e}) + h(N\bar{e}) \frac{dP(\cdot)}{de} \right] + \frac{N-1}{N^2 \bar{e}} h(N\bar{e}) P(N\bar{e}) - \frac{dc(\cdot)}{de} = 0$$

where $P(N\bar{e}) = \alpha - \beta h(N\bar{e})$.

When $N = 1$, the equilibrium is optimal; marginal revenue equals marginal cost.

When $N > 1$, the equilibrium is no longer optimal and the equilibrium effort increases up to where average revenue equals marginal cost.

We apply the model to a fishery within a season of $t = 1, \dots, T$ weeks (Gardner, Moore, & Walker, 1997). Following Anderson and Uchida (2014), we assume zero discount rate and no stock effect on the harvest function. The maximization problem becomes:

$$\max_{e_{it}, T} \quad \pi_{it} = \sum_{t=1}^T \left\{ \frac{e_{it}}{E_t} h(E_t) [\alpha - \beta h(E_t)] - c(e_{it}) \right\}$$

$$\text{subject to} \quad 0 \leq e_{it} \leq e_{max}$$

$$T \leq T_{max}$$

$$\sum_{t=1}^T h(E_t) \leq m\bar{q} \text{ for a CP group}$$

$$\sum_{t=1}^T h(e_{it}) \leq \bar{q} \text{ for IQ players.}$$

CP and IQ players face the same maximization problem except that their total harvest for a season is constrained to collective quota for players under CP management and individual quota for IQ management.

Consider the specific parameter values chosen for the game (Table 1.1). In the parameterization used, subgame perfect equilibrium is for all identical players to choose IQ, and play a Nash equilibrium strategy of constant average effort of 1.92 days in all weeks in the continuous fishing game. The symmetric Nash equilibrium under CP management is, regardless of m , at e_{max} , which is less than at a point where average revenue equals marginal cost. Notice that a Total Allowable Catch (TAC) quota ($= N\bar{q}$) is “binding”; a TAC is relatively scarce compared to a potential total catch ($= T_{max}h(E_{max})$). In such a case, the optimal harvesting strategy for IQ players is to time the landings to equalize the total landings from both groups throughout a season and thus $h(E^*) = N\bar{q}/T_{max}$. Table 1.2 presents all Nash equilibria contingent on an outcome of management choice in the first stage.

Measurement of Risk Preferences

To explain variation in management choices, subjects completed three

supplemental instruments. To measure risk attitudes, we used a elicitation method for risk aversion by Holt and Laury (2002). Players choose which lottery to enter, either “safe” or “risky,” for every pair of ten pairs (Table 1.3). The stakes are \$2 and \$1.60 for the “safe” lottery and \$3.85 and \$0.10 for the “risky” lottery. The probability of winning the higher payoffs in both lotteries starts with ten percent and increases. Conversely, the probability of winning the lower payoffs in both lotteries starts with 90 percent and decreases. Players switch at some point from the “safe” lottery to the “risky” lottery. This switch identifies the range of relative risk aversion. While risk seeking players switch to the “risky” option before the expected utility of the “risky” lottery is less than the “safe” lottery, risk averse players stick to the “safe” option even after the expected utility of the “safe” lottery is greater than the “risky” lottery.

Measurement of Other-regarding Preferences

We conducted the ultimatum game for the stake of \$10. In the two-player ultimatum game, one player is designated as a “Proposer” and makes an offer to divide \$10 between oneself and the other player. If the other player designated as a “Responder” accepts the offer, the payoffs for the two players are realized as proposed. If a “Responder” rejects the offer, both get nothing. In the strategy method of the ultimatum game subjects are asked for their contingent behaviour in both roles, choosing an offer from \$0 to \$10 in an increment of \$1 as a Proposer and responding to every possible proposal as a Responder. Subjects are randomly paired and assigned a role after all decisions are made. Although the prediction of the game is that a self-interested “Proposer” gives the smallest amount of money to the “Responder” and the “Responder” accepts any amount because even the smallest amount is better than

nothing, low offers in the ultimatum game were frequently rejected (Camerer & Thaler, 1995; Roth, Prasnikar, Okuno-Fujiwara, & Zamir, 1991). Fehr and Schmidt (1999) modeled this seemingly irrational behaviour and defined fairness as inequality aversion and incorporated the idea that some people experience disutility from unequal distribution of payoffs. We derived individual inequality aversion parameters following Fehr and Schmidt (1999)'s two-player model for inequality aversion as follows:

$$U_i(x) = x_i - \alpha_i \max[x_j - x_i, 0] - \beta_i \max[x_i - x_j, 0], \quad i \neq j,$$

where x is the amount of money received. The responses as a Proposer in the ultimatum game identify the coefficient α_i , which represents the degree of utility loss from disadvantageous inequality.

Measurement of Preference for Competition

We used the psychological survey developed by Smither & Houston (1992) and Houston et al. (2002). Subjects completed a five-point Likert-scale survey instrument on attitudes toward competition (Table 1.4), with nine questions yielding an index of enjoyment of competition in the range of 9 to 45 (most enjoyment) and five questions forming an index of contentiousness from 5 to 25 (most contentious). We used this survey instead of other commonly used surveys for competitiveness such as Work and Family Orientation Questionnaire (Helmreich & Spence, 1978) because our interests are not competition in a specific context such as work or self-achievement but in general attitude toward competition.

Procedures

The experiment took place at Policy Simulation Laboratory at University of Rhode Island during the semesters of fall 2011 and spring 2012. Each session lasted approximately two hours with twelve participants, who were recruited through undergraduate economics classes. In total nine sessions were conducted, which produced a sample of 107 subjects (one subject did not complete the experiment). Subjects were paid a \$5 appearance fee, plus earnings from three random fishing games, one random lottery, and the ultimatum game. Subjects started with the ultimatum game using pencils and paper, and then played the two-stage fishing game over a local computer network facilitated by a Java based software (Figure 1.1). After the tenth round of the fishing game the survey for competition was conducted in a paper-based format, and the rest of the game resumed. Finally the lottery choice was administered through VeconLab (<http://veconlab.econ.virginia.edu/introduction.php>). The Appendix contains the written instructions for the two-stage fishing game.

1.3 Data analysis

Figure 1.5 shows the frequency of subjects' choosing IQ rises from half in the first two seasons (mean = 51.9%; SE = 3.4%) to over 80 percent of subjects in the last two seasons (mean = 83.3%; SE = 2.5%). More than 40 percent of the subjects consistently chose IQ during later seasons (mean = 43.5%; SE = 4.8% for seasons 11-20). A small portion of the subjects, less than 5 percent, never tried the CP management and remained in IQ throughout the session (mean = 4.6%; SE = 2.0% for all seasons). About 14 percent of the subjects persistently—twice or more in the last five seasons—

chose CP even at the end of the sessions (mean = 13.9%; SE = 3.3% for seasons 16-20).

Subjects employ different fishing strategies based on their own management group (two-tailed Mann-Whitney $z = -24.690$, $P = 1.37e^{-134}$), and the number of subjects choosing CP, consistent with equilibrium predictions (Figure 1.2). Mixed-effects model for predicting mean effort level in IQ suggests that subjects smooth out effort throughout the season from 2.21 days at week 1 to 1.86 days at the last week when all subjects are in IQ (11 or 12 subjects picked IQ in 23 of 90 seasons) (Table 1.5). The dependent variable, \bar{e}_{ijkt} , is mean effort level in management choice i , week t , season k , session j . Included in regression are a week trend variable, a binary variable to indicate whether the CP fishery is open at week t , and a binary variable that takes 1 if the number of subjects in IQ is 10 and greater or 0 otherwise.

$$\begin{aligned}\bar{e}_{ijkt} = & \beta_{i0} + \beta_{i1}week_{ijkt} + \beta_{i2}CP_open_{ijkt} + \beta_{i3}IQ_strategy_{ijk} + \beta_{i4}week_{ijkt} \\ & \times CP_open_{ijkt} + \beta_{i5}week_{ijkt} \times IQ_strategy_{ijk} + \beta_{i6}IQ_strategy_{ijk} \\ & \times CP_open_{ijkt} + \beta_{i7}week_{ijkt} \times IQ_strategy_{ijk} \times CP_open_{ijkt} + u_{ij} \\ & + u_{ijk} + \varepsilon_{ijkt}\end{aligned}$$

The same model for CP shows that when subjects choose CP, they fish intensively, but the derby is less intense than the 7 days predicted, and thus CP closure is 2-3 weeks later than predicted (Table 1.5). IQ subjects respond to the CP derby by holding back effort, increasing by 1.66 days after CP closure.

Subjects' movement toward IQ follows significantly higher profits (Figure 1.5, right axis) (Mann-Whitney test, $z = -13.773$, $P = 3.705e^{-43}$, two-tailed), with IQ subjects earning more (mean = \$71,092; SE = 181) than CP subjects (mean = \$61,218; SE = 875). Regardless of the number of subjects that choose CP, average profits in IQ

are higher (Figure 1.3). CP subjects earned less on average but with a greater variability. We estimated profits and standard deviation of profits using mixed effects model with heteroskedastic errors (Table 1.6). The dependent variables, $Profit_{ikt}$ and SD_{kt} , are subject i 's profit earned in session k , season t and standard deviation of profits in session k , season t , respectively. Included in regression are a season trend variable, a binary variable to indicate whether a subject is in IQ at season t , and the number of subjects in CP excluding oneself at season t . The model is allowed to produce systematically different error variance between CP and IQ.

$$Profit_{ikt} = \beta_0 + \beta_1 season_{ikt} + \beta_2 season_{ikt}^2 + \beta_3 choice_{ik} + \beta_4 choice_{ik} \times season_{ikt} + \beta_5 choice_{ik} \times season_{ikt}^2 + \beta_6 CP_subjects_{ik} + \beta_7 choice_{ik} \times CP_subjects_{ik} + u_k + u_{ik} + \varepsilon_{ikt}$$

$$SD_{kt} = \beta_0 + \beta_1 season_{kt} + \beta_2 season_{kt}^2 + \beta_3 choice_k + \beta_4 choice_k \times season_{kt} + \beta_5 choice_k \times season_{kt}^2 + \beta_6 CP_subjects_k + \beta_7 choice_k \times CP_subjects_k + u_k + \varepsilon_{kt}$$

The results indicate an additional subject choosing CP reduces CP subject profits by \$1,390, and increases IQ subject profits by \$1,230 (Table 1.6). This controls for the number of CP subjects, and a significant effect of experience, wherein average profits increase linearly over time by \$1,150 per season. However, profits in CP range from considerably less than in IQ, to considerably more (Figure 1.3). CP subjects have significantly greater within-season profit variance, with a standard deviation \$17,267 higher than IQ (Table 1.6). The median difference between season top and bottom CP profits during the last 10 seasons is \$17,185 whereas in IQ is \$11,383. In the same period, 42 percent (38 out of 90 seasons) of the top season earnings was by CP subjects, and 15 different individuals contributed to this high earnings in CP. Among

90 season top earnings, the median in 38 CP profits is \$91,400 and in 52 IQ profits is \$77,633.

The choice of management groups (1 if IQ; 0 if CP) is modeled with a random effects logit model. Explanatory variables include the coefficient of constant relative risk aversion (CRRA) from the lottery choice game; the parameter of inequality aversion from the ultimatum game; two psychological competitiveness indices; the profit the subject received last time she fished in IQ minus the profit last time she fished in CP (substituting the mean for inexperienced subjects); the number of subjects in CP in the previous season excluding oneself; and binary catch, which is coded 1 if in the previous season the subject was in CP and caught more than her 3000lb IQ quota, or 0 otherwise (Tables 1.7-1.8).

$$\begin{aligned} Pr(Choice_{ikt} = IQ) \\ = F(\beta_0 + \beta_{\omega 1} competition_{ik} + \beta_{\omega 2} contentiouness_{ik} + \beta_{\omega 3} risk_{ik} \\ + \beta_{\omega 4} inequality_{ik} + \beta_{\omega 5} CP_subjects_{ik(t-1)} + \beta_{\omega 6} catch_{ik(t-1)} \\ + \beta_{\omega 7} profit_{ik(t-1)} + u_{ik}) \end{aligned}$$

The dependent variable, $Choice_{ikt}$ is subject i 's choice of management system in session k , season t and takes 1 if choosing IQ or 0 if CP.

Each independent variable is interacted with both an increasing and a decreasing sigmoid function of season number (with estimated switchover point) to capture the evolution of the role of the explanatory variables as subjects gain experience in each management institution (Myagkov & Plott, 1997).

$$\text{Sigmoid function: } \omega = 1 / (1 + e^{(season - \beta) * \alpha})$$

The parameter α takes an arbitrary value 1 for the decreasing function and $-\alpha$ for the increasing function. The parameter β determines the slope of the curve and thus the

switchover point of the two curves. The model estimation for different values of β is shown in Table 1.9. Figure 1.4 shows the final form of the Sigmoid function.

This model identifies the factors that are most explanatory of management choice (Table 1.10, Figure 1.6). The difference between the subjects' most recently experienced profit in each system is the only variable significant across seasons at conventional levels: a marginal increase in difference between IQ and CP profits increases the probability of choosing IQ by 2.1% in early seasons. This increase reaches 4.7% as subjects gain experience and experiment less over time. The only other explanatory variable that is significant among experienced subjects is the Enjoyment of Competition index, where a marginal increase in the Enjoyment of Competition subscale decreases the probability of choosing IQ by 5.4%.

This also resonates with the fact that those who opted into CP still raced to fish even when no one else was in CP. When there is only one subject in CP, it is practically the same as everyone being in IQ; yet, a good number of the subjects in CP when they are the only one in the group exerted their effort differently from the rest of the subjects who opted into IQ (two-tailed Mann-Whitney $z = -6.049$, $P = 1.457e^{-9}$). Forty two percent of the subjects in CP when everyone else is in IQ finished their quota by the week of 20, which implies that their harvesting strategies closely followed the Nash equilibrium in CP that results in a closure of the fishery in the week of 15.

Other variables are not significant drivers of long-run preferences for IQ. In early seasons when subjects are experimenting, inequality aversion is low-level significant—and shows more inequality averse people choosing the more unequal

CP—but the effect is insignificant after the early experimentation phase. Despite a clear mean-variance tradeoff, CRRA is nominally small and does not significantly explain choice. The quantity of catch is insignificant, reflecting that subjects are likely focusing on profit rather than quantity in their decision. The number of (other) CP subjects in the previous season shifts from increasing the chance of choosing CP by six percent—following a herd into CP—in the early seasons, to decreasing it by six percent as subjects find small CPs more profitable, but is insignificant throughout.

1.4 Discussion

Although subjects could have chosen inefficient collective use of a resource appropriation right, an overwhelming majority of subjects moved systematically toward the institution with stronger property rights, individual quotas. This modified their harvesting strategy and moved the aggregate harvest pattern close to the optimal pattern that would be pursued by a sole owner, which increased prices received, harvester profitability, and efficiency. Rhode Island fluke sector pilot program, the motivating case of this manuscript, also went through a similar change during its three-year existence. The pilot program began with eight boat owners occupying 11.53% of the state's allocation, and the membership size grew to 13 receiving 15.7% of the allocation as more boat owners decided to join after witnessing higher profits and more flexible operation by the members (Scheld, Anderson, & Uchida, 2012; Wilson, 2012).

However, a persistent minority of subjects remained in the common pool, earning lower profits, and the Rhode Island fluke fishermen who did not join the

sector continued to opt to operate under the conventional regulatory scheme. These subjects did so intentionally, knowingly foregoing the higher profits they—individually—earned in seasons when they chose an individual allocation of quota. This behavior is explicable as an expression of a taste for competition, as captured by the Enjoyment of Competition index in the Houston et al. instrument.

That fishermen have a preference for competition is not new, and regret at the loss of a competitive element is sometimes expressed following rationalization; it is no surprise that competitive people would select into derby fishing as an occupation. Even under the management system such as revenue sharing arrangement, in which competition is disincentivised, anecdotal evidence suggests that fishers still like to compete under such system (Gaspart & Seki, 2003; Platteau & Seki, 2001; Manuscript 2 in this dissertation). This may be an important insight into how or why complete individual allocation is difficult to implement in its totality in many fisheries, despite a track record of higher incomes. The combination of people unsure about the system (96% of subjects tried the common pool at some point) and those who derive utility from the inefficient aspects of the old system may prevent implementation as a final measure. However, a catch share system where groups receive allocations they can manage in any way they choose allows those willing to give up some income for other aspects of the job or lifestyle to affiliate and do so. It also provides easy, non-regulatory reversibility; if it turns out an individual does not find a legacy management group to their liking, they can switch to another group with a different management system.

Thus, the outcome observed from the catch share system moved strongly toward, but not all the way to, the sole owner solution. However, since not all harvesters had to adopt the individual quota, the catch share provided an additional degree of Pareto safety—preserving the element of competition for those harvesters who value it over marginal income—and made implementation and significant aggregate welfare gains possible. To agencies whose objectives encompass outcomes to populations beyond harvesters, the persistence of inefficiencies attributable to utility maximization of harvesters who prefer inefficient systems can be worrisome. However, the pattern that this persistence diminishes—without regulatory intervention—as the catch share system matures may provide solace.

More broadly, the present experiment suggests effort spend articulating and implementing many details of management systems is unnecessary; in cases where building consensus or political majorities around these details delays or prevents reform, it is destructive. Rather, management institutions continue to evolve when the managed parties have sufficient flexibility in the use of the right, even a right they can transfer.

This is the self-governance literature's fundamental insight, viewed through a different lens; under the right conditions, users of a resource can develop governance systems that support sustainable rent generation. However, many of the case studies emphasize the community, taking the properties of the resource as exogenous. Some of the key enabling resource properties can be functionally implemented with a right; even collective quotas provide well-defined boundaries of both the resource and the user group. Their role in Ostrom's framework is to facilitate consensus about who can

access the resource, predicate to establishing consensus around use levels. With the aggregate level of extraction determined, and thus the sustainability problem resolved, other community factors can then be brought to bear on harvesting the resource for rent maximization. This does not conflict with the self-governance, but rather shows how the benefits of self-governance can work in a broader set of cases, cases much more typical of commercial fishery resource users worldwide.

Given current tensions in the social science of resource management literature, it would be a terrific irony if the key to implementing community-based self-governance was a weak individual property right, along with sufficient autonomy to determine how it is exercised. While it was the preferred institution in the limited choice set available in this experiment, this is not to argue that strong individual property rights are the solution for the sector-based management. Cooperatives that pool or collectively manage individual allocations are common; Chignik was designed to facilitate cost-reducing coordination among the collective allocations, and in the West Coast US groundfish fishery, large heterogeneous groups of harvesters initially allocated individual transferable rights have pooled some of them to manage choke species (Holland and Jannot 2012), and some smaller groups have fully pooled quota, adopting cost minimizing coordinated harvest strategies (e.g., Ilwaco Fishermen Marketing Cooperative). To implement collective catch shares more effectively, however, we need theory and research to understand the conditions under which sectors managed by catch shares initially adopt one management system rather than another, and how those systems evolve as users gain experience with their chosen system, and observe outcomes under others.

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Table 1.1 Parameters for continuous fishing game.

Number of subjects	N	12
Maximum effort level	e_{max}	7
Number of weeks	T_{max}	52
Individual Quota (lbs)	\bar{q}	3,000
Collective Quota (lbs)	$m\bar{q}$	m is number of CP subjects
Cost function	$c(\cdot)$	$500 * e_{it}$
Harvest function	$h(\cdot)$	$30 * e_{it}$
Parameters	α	50
	β	0.012

Table 1.2 Nash equilibrium in the continuous fishing subgame, conditioned on the outcome of management choice. The parameters used are specified in Table 1.1. The strategy for IQ specifies mixed strategy because of multiple pure strategy equilibria. Resulting profits are derived by pure strategy. When there are 11 subjects in IQ and 1 subject in CP, it is strategically the same as all subjects in IQ and thus combined together. *This indicates the mean of the profits derived by pure strategy Nash equilibria.

Management systems	Weeks	Days per week	Profit
All IQ			
12 IQ subjects	1-52	1.92	75,074
Mixed			
10 IQ subjects	1-14	0.93	75,117
	15	1.9	
	16-52	2.3	
2 CP subjects	1-14	7	74,858
	15	2	
	16-52	Closed	
9 IQ subjects	1-14	0.25	75,146*
	15	1.89	
	16-52	2.56	
3 CP subjects	1-14	7	74,858
	15	2	
	16-52	Closed	
8 IQ subjects	1-14	0	77,034*
	15	1.75	
	16-52	2.66	
4 CP subjects	1-14	7	69,890
	15	2	
	16-52	Closed	
7 IQ subjects	1-14	0	79,813*
	15	1.29	
	16-52	2.67	
5 CP subjects	1-14	7	62,546
	15	2	
	16-52	Closed	
6 IQ subjects	1-14	0	82,619*
	15	0.83	
	16-52	2.68	
6 CP subjects	1-14	7	55,180
	15	2	
	16-52	Closed	
5 IQ subjects	1-15	0	85,385*
	16-52	2.7	
7 CP subjects	1-14	7	47,836
	15	2	
	16-52	Closed	
4 IQ subjects	1-15	0	88,309*
	16-52	2.7	
8 CP subjects	1-14	7	40,384
	15	2	
	16-52	Closed	
3 IQ subjects	1-15	0	91,230
	16-52	2.7	
9 CP subjects	1-14	7	32,932
	15	2	
	16-52	Closed	
2 IQ subjects	1-15	0	94,114
	16-52	2.7	
10 CP subjects	1-14	7	25,480
	15	2	
	16-52	Closed	
1 IQ subjects	1-15	0	96,998
	16-52	2.7	
11 CP subjects	1-14	7	18,028
	15	2	
	16-52	Closed	
All CP			
12 CP subjects	1-14	7	10,576
	15	2	
	16-52	Closed	

Table 1.3 Lottery choice

Safe option	Risky option
10% of \$2.00, 90% of \$1.60	10% of \$3.85, 90% of \$0.10
20% of \$2.00, 80% of \$1.60	20% of \$3.85, 80% of \$0.10
30% of \$2.00, 70% of \$1.60	30% of \$3.85, 70% of \$0.10
40% of \$2.00, 60% of \$1.60	40% of \$3.85, 60% of \$0.10
50% of \$2.00, 50% of \$1.60	50% of \$3.85, 50% of \$0.10
60% of \$2.00, 40% of \$1.60	60% of \$3.85, 40% of \$0.10
70% of \$2.00, 30% of \$1.60	70% of \$3.85, 30% of \$0.10
80% of \$2.00, 20% of \$1.60	80% of \$3.85, 20% of \$0.10
90% of \$2.00, 10% of \$1.60	90% of \$3.85, 10% of \$0.10
100% of \$2.00, 0% of \$1.60	100% of \$3.85, 0% of \$0.10

Source: Holt & Laury (2002), p. 1645.

Table 1.4 Competitiveness index. *This indicates reverse scored.

Subscale	Question
Enjoyment of Competition	1 I like competition.
	2 I am a competitive individual.
	3 I enjoy competing against an opponent.
	4* I don't like competing against other people.
	5 I get satisfaction from competing with others.
	6* I find competitive situations unpleasant.
	7* I dread competing against other people.
	8* I try to avoid competing with others.
	9 I often try to outperform others.
Contentiousness	10* I try to avoid arguments.
	11* I will do almost anything to avoid an argument.
	12* I often remain quiet rather than risk hurting another person.
	13* I don't enjoy challenging others even when I think they are wrong.
	14* In general, I will go along with the group rather than create conflict.

Source: Houston et al. (2002)

Table 1.5 Mixed-effects model estimation of weekly mean effort level. In parenthesis are z score. The data used include the observations from the last half of the sessions, season 11 to 20. The first and last three weeks of each season are excluded in regression.

Independent variables	Dependent variable:	
	Mean effort level in IQ	Mean effort level in CP
Week	-0.0175 (10.38)**	0.0038 (1.74)
CP open (1 if CP is open, 0 otherwise)	-1.6616 (21.70)**	5.4001 (54.56)**
Week X CP open	0.0486 (12.08)**	0.0028 (0.54)
IQ strategy (1 if more than 9 subjects are in IQ, 0 otherwise)	-0.6168 (9.07)**	0.0075 (0.06)
Week X IQ strategy	0.0108 (5.63)**	0.0003 (0.11)
IQ strategy X CP open	1.2781 (13.46)**	0.419 (3.33)**
Week X IQ strategy X CP open	-0.0446 (8.58)**	-0.0385 (5.54)**
Constant	2.8367 (45.55)**	-0.1863 (1.59)
Variance component		
Random effects for sessions	-3.1348 (10.11)**	-1.6499 (5.22)**
Random effects for seasons, sessions	-18.2241 (6.81)**	-1.0885 (12.63)**
Error	-0.6949 (63.16)**	-0.4407 (39.65)**
Observations	4,140	4,140
Wald Chi2 (7)	1033.23**	47413.39**

* $p < 0.05$; ** $p < 0.01$

Table 1.6 Heteroskedastic mixed-effects model estimation. In parenthesis are z score.

Independent Variables	Dependent variable:	
	Profits	Standard deviation of profits
Season	1,149.56 (1.85)	122.82 (0.13)
Season^2	-31.8 (1.1)	-9.92 (0.24)
Choice (1 if IQ)	-757.79 (0.16)	-17,267.30 (2.50)*
Choice X Season	685.9 (1.09)	-403.12 (0.43)
Choice X Season^2	-29.53 (1.01)	13.6 (0.32)
The number of subjects in CP	-1,389.65 (2.34)*	-570.77 (0.6)
Choice X The number of subjects in CP	1,229.93 (2.04)*	1,085.01 (1.14)
Constant	61,165.63 (13.30)**	23,479.90 (3.42)**
Variance component		
Random effects for date	7.2 (16.40)**	7.15 (26.26)**
Random effects for subjects	8.3 (104.00)**	
Random effects for CP	9.88 (305.91)**	9.57 (162.71)**
Random effects for IQ	8.48 (453.32)**	7.71 (142.39)**
ln(likelihood)	-22,357.14	-3,336.24
Wald Chi2 (df = 7)	941.39	301.59
Observations	2,160	333

* $p < 0.05$; ** $p < 0.01$

Table 1.7 Summary statistics. Infinity for inequality aversion parameter is replaced with linear extrapolation. For profit difference, missing value until you experience both choices is replaced with the mean profit of the group in the season.

Variable	Obs	Mean	Std. Dev.	Min	Max
Competitiveness Index: Enjoyment of Competition	108	34.58	6.27	11	45
Competitiveness Index: Contentiousness	107	16.15	4.20	6	25
Risk Attitudes	108	0.50	0.46	-0.96	1.38
Inequality Aversion	108	4.92	5.18	0	12
The number of CP choosers excluding oneself, lagged	2,052	3.06	1.65	0	9
Binary catch (1 if catching more than IQ, 0 otherwise), lagged	2,052	0.13	0.34	0	1
Profit difference (latest experienced profits in IQ - CP)	2,052	1.55	2.06	-9.14	7.34
choice (1 if IQ, 0 if CP)	2,160	0.73	0.45	0	1

Table 1.8 Correlation matrix of explanatory variables.

	Competitiveness index subscale 1, std	Competitiveness index subscale 2, std	Coefficient of CRRA, std	Inequality aversion, std	ln(The number of other CP choosers excluding oneself), lagged	Binary catch (1 if catching more than IQ, 0 otherwise), lagged	Profit difference (latest experienced profits in IQ-CP)
Competitiveness index subscale 1, std	1						
Competitiveness index subscale 2, std	0.26	1					
Coefficient of CRRA, std	0.01	0.09	1				
Inequality aversion, std	0.15	0.02	0.07	1			
ln(The number of other CP choosers excluding oneself), lagged	-0.06	0.01	-0.01	0.03	1		
Binary catch (1 if catching more than IQ, 0 otherwise), lagged	0.10	0.06	0.04	0.01	0.06	1	
Profit difference (latest experienced profits in IQ-CP)	-0.09	-0.18	0.04	0.05	-0.05	-0.54	1

Table 1.9 Selection of the parameter for the Sigmoid function. The model is the same as Table 1.10. N=Obs used in calculating BIC.

Beta	Obs	Log Likelihood	df	AIC	BIC
1	2033	-916.21	16	1864.43	1954.30
2	2033	-915.72	16	1863.43	1953.31
3	2033	-915.10	16	1862.19	1952.07
4	2033	-914.46	16	1860.92	1950.79
5	2033	-913.65	16	1859.30	1949.17
6	2033	-912.47	16	1856.95	1946.82
7	2033	-910.96	16	1853.91	1943.79
8	2033	-909.38	16	1850.75	1940.63
9	2033	-908.21	16	1848.42	1938.29
10	2033	-907.73	16	1847.47	1937.34
11	2033	-908.12	16	1848.24	1938.12
12	2033	-909.30	16	1850.61	1940.48
13	2033	-910.79	16	1853.58	1943.45
14	2033	-912.38	16	1856.76	1946.63
15	2033	-913.87	16	1859.73	1949.61
16	2033	-914.72	16	1861.43	1951.31
17	2033	-915.00	16	1862.00	1951.88
18	2033	-915.39	16	1862.77	1952.65
19	2033	-916.27	16	1864.55	1954.42
20	2033	-917.42	16	1866.84	1956.72

Table 1.10 Random Effects Logit Model of Choice of IQ. All variables are standardized except for binary catch. In parenthesis are z score. AME denotes average marginal effects.

Indep. Variables		Coef.	AME
Later seasons	Enjoyment of competition	-0.36 (2.22)*	-0.054 (2.22)*
	Contentiousness	0.04 (0.25)	0.006 (0.25)
	Coefficient of CRRA	-0.05 (0.37)	-0.008 (0.37)
	Inequality aversion	-0.23 (1.64)	-0.035 (1.65)
	ln(The number of other CP choosers excluding oneself), lagged	0.42 (0.74)	0.063 (0.74)
	Binary catch (1 if catching more than 3000lb, 0 otherwise), lagged	-0.27 (0.83)	-0.040 (0.83)
	Profit difference (latest experienced profits in IQ - CP)	0.31 (8.11)**	0.047 (8.06)**

Early seasons	Enjoyment of competition	-0.18 (1.23)	-0.027 (1.23)
	Contentiousness	0.22 (1.57)	0.033 (1.58)
	Coefficient of CRRA	-0.09 (0.69)	-0.014 (0.69)
	Inequality aversion	-0.27 (2.07)*	-0.041 (2.09)*
	ln(The number of other CP choosers excluding oneself), lagged	-0.4 (0.92)	-0.059 (0.92)
	Binary catch (1 if catching more than 3000lb, 0 otherwise), lagged	-0.26 (0.92)	-0.038 (0.98)
	Profit difference (latest experienced profits in IQ - CP)	0.14 (4.66)**	0.021 (4.75)**

Constant		0.7 (2.94)**	
Random effects for subjects		0.01 (0.03)	
Ln(likelihood)		-907.51	
Wald Chi^2 (df = 14)		178.73**	
Obs		2,033	
Num of groups		107	

* $p < 0.05$; ** $p < 0.01$			

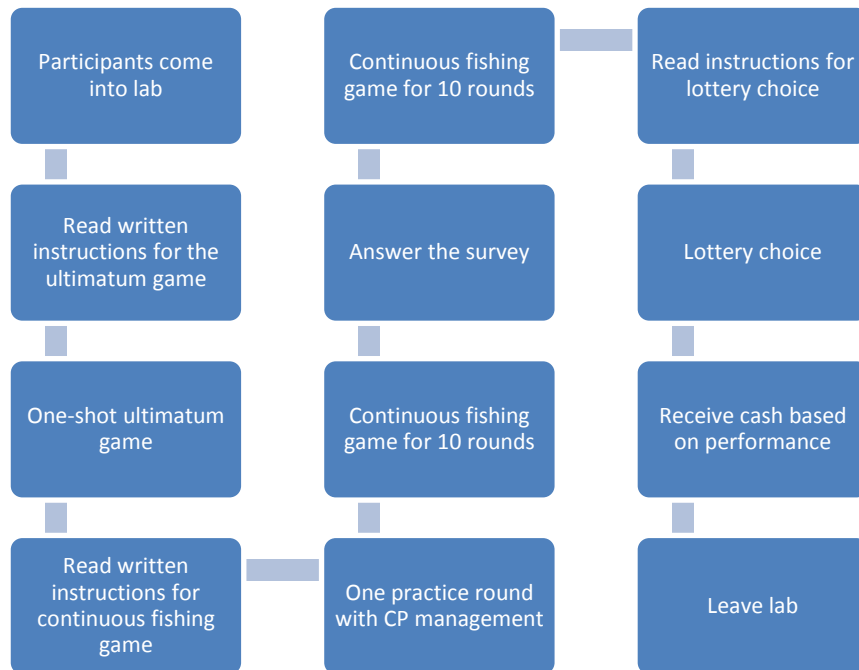


Figure 1.1 Flow of experiment.

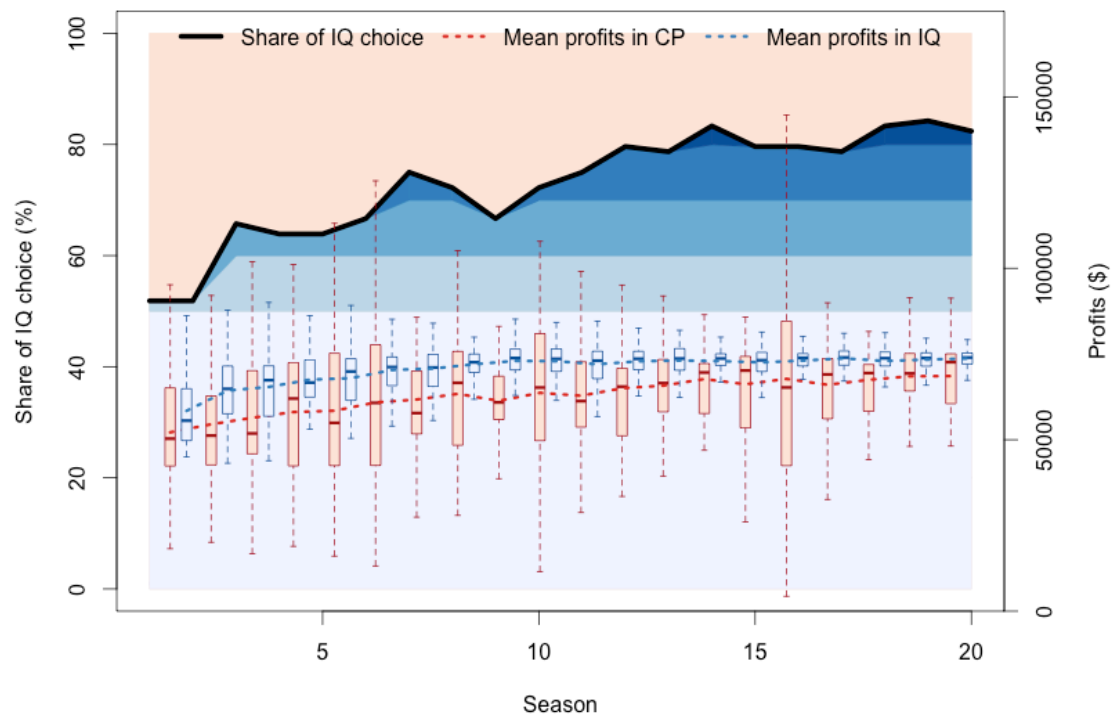
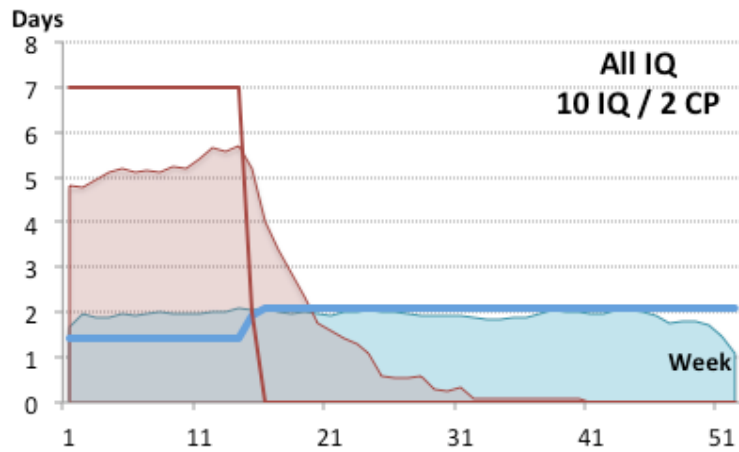


Figure 1.2 Choice of management group, and corresponding profits, over time.

A.



B.

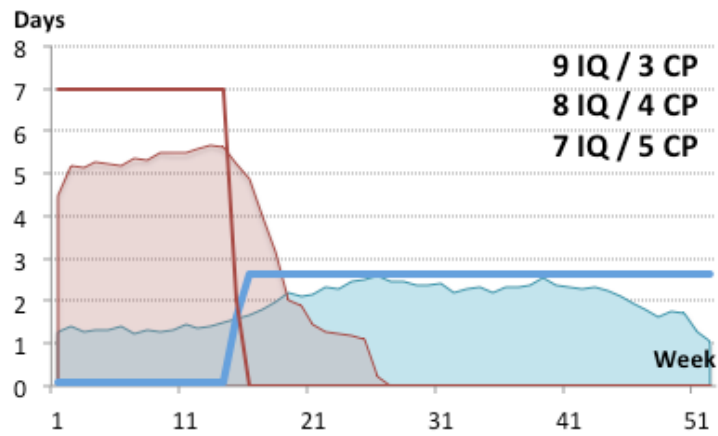


Figure 1.3 Comparison between Predictions and Observations. The data used include the observations from the last half of the sessions, season 11 to 20. Blue colour stands for IQ and red for CP. Shaded areas are observations and lines are predictions. (A) Shown is the mean of days per week across the two outcomes: all subjects in IQ and 10 subjects in IQ (2 subjects in CP). (B) Shown is the mean of days per week across the three outcomes: 9 subjects in IQ (3 in CP), 8 subjects in IQ (2 in CP), and 7 subjects in IQ (5 in CP).

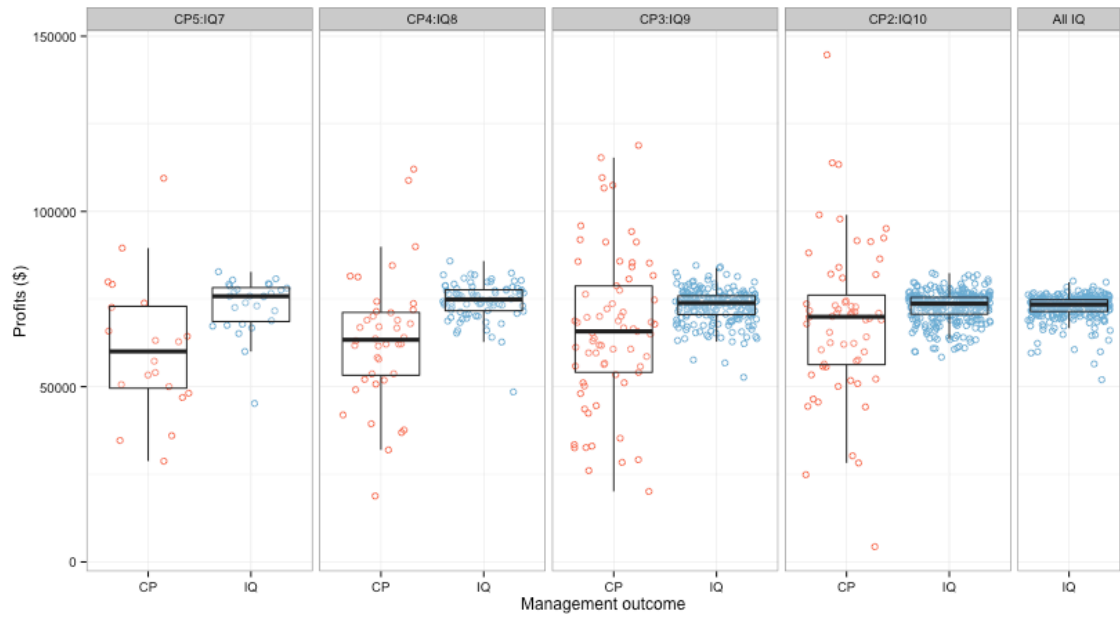


Figure 1.4 Distribution of profits by each management outcome. The data used include the observations from the last half of the sessions, season 11 to 20.

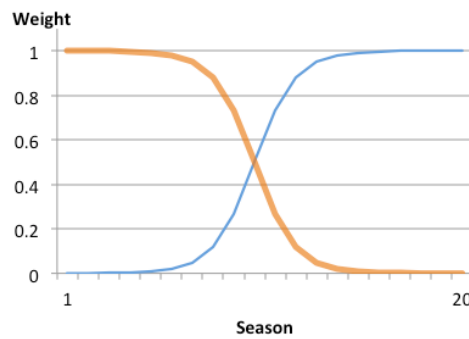


Figure 1.5 Weight for the two estimates when $\beta = 10$.

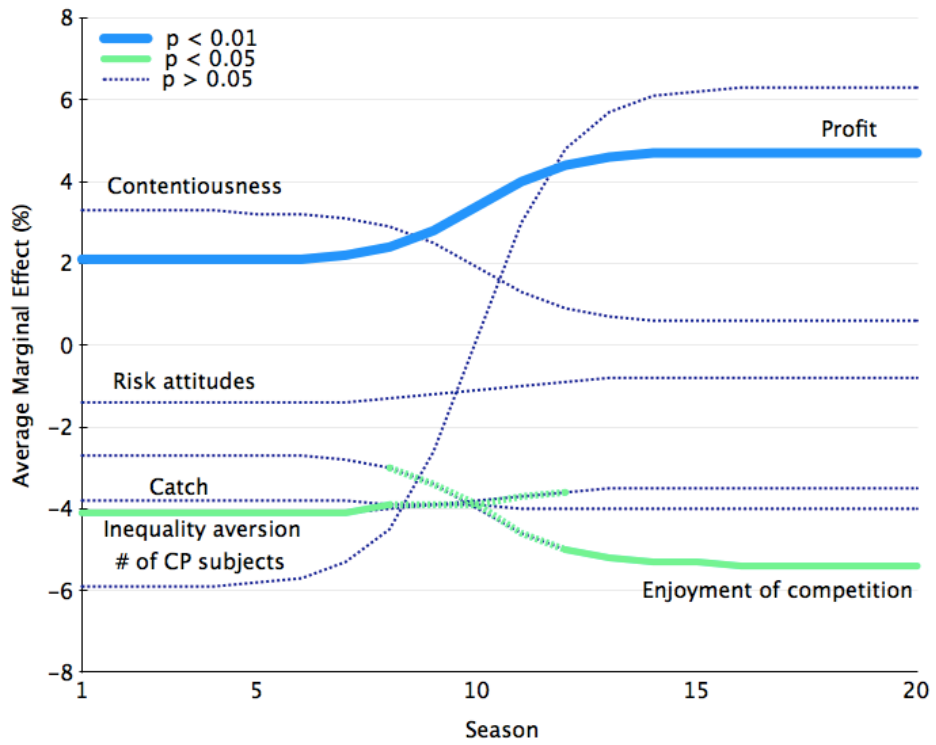


Figure 1.6 Average Marginal Effect. Shown is average change in the probability of choosing IQ, caused by a marginal increase in the named independent variable. All explanatory variables except for the binary catch are X-standardized and, for time-varying variables, standardized by standard deviation at the corresponding time.

Appendix 1.1 Additional Analysis

Estimating Group Choice

How risk attitudes influence choice is uncertain throughout the session (Table 1.10). Choosing CP can accompany opportunity of earning tremendous profits that are not usually possible in IQ. Maximum profit earned in CP is twice as great as the mean of profits in IQ during the last ten seasons. This may drive risk seeking subjects towards CP. Risk attitudes can act on when subjects see such a chance in CP by experiencing greater standard deviation in CP relative to IQ. To further investigate, we estimated the same random-effects logit model but with two subcategories for risk attitudes instead of a single coefficient: risk seeking subjects and risk averse subjects both interacted with the original coefficient and the level of relative dispersion of profits in the previous season (Tables 1.11, 1.12). The level of relative dispersion of profits is defined as difference between estimation of standard deviation of CP and IQ profits across all sessions in the previous season. This longer model is expected to capture different responses from risk seekers and averters on different levels of profit dispersion. However, we did not find any evidence of risk attitudes influencing choice (Table 1.12).

Although it is significant for early seasons, the implication of the disadvantageous inequality aversion variable is puzzling. Marginal increase in the coefficient decreases the probability of choosing IQ by 4.1 percent at the beginning of the sessions, all things equal. As fishing in CP results in a wider profit distribution, more inequality averse subjects are expected to select IQ to avoid such inequality. However, the estimation suggests the opposite during early seasons. The less averse

subjects are to disadvantageous inequality, the more likely they are to choose IQ. If it in fact captures the level of aversion to disadvantageous inequality, this coefficient should be in play when subjects earn fewer profits than their expectation.

The degree of inequality aversion may matter as more inequality averse subjects may respond differently from less inequality averse subjects. The coefficient of inequality aversion takes six values (0, 0.125, 0.334, 0.75, 2, infinity) with the percent of each value (2.8%, 12%, 2.8%, 13.9%, 34.3%, 34.3%). Non-parametric test suggests that the coefficient of 2 and greater make distinct choice from others (Mann-Whitney test, $z = 5.140$, $P = 2.747e^{-07}$, two-tailed). In addition, differentiating a kind of inequality subjects experienced can improve the estimation, and subjects at different degrees of inequality aversion can react distinctly to various kinds of inequality. We divided inequality aversion into two categories: advantageous inequality and disadvantageous inequality. Advantageous inequality is defined as a difference of experienced profit minus estimated profit if experienced profit is greater than estimation and 0 otherwise. Similarly disadvantageous inequality is defined as a difference of estimated profit minus experienced profit if estimated profit is greater than own experience and 0 otherwise. We created the two variables each in CP and IQ (Table 1.11). Finally we interacted the parameter of inequality aversion with two binary variables indicating the degree of inequality aversion and four kinds of inequality in all combinations, yielding eight variables in total (Table 1.12).

We estimated the same random-effects logit model, breaking down a single coefficient into subcategories based on whether or not a subject is more inequality averse and whether or not a subject experienced disadvantageous (or advantageous)

inequality of profits in IQ (or CP) in the previous season (Table 1.12). According to this model significance during initial seasons is attributable to the behaviour when more inequality averse subjects face disadvantageous inequality in CP. The experience of having been taken advantage of in CP can make more inequality averse subjects emotional, which drives them into the seemingly irrational choice (Koenigs & Tranel, 2007). More inequality averse subjects, who rejected low offers in the ultimatum game, were identified as possessing higher testosterone levels, suggesting that they are more aggressive, emotional, and dominant (Burnham, 2007). The results suggest that emotion plays an important role in economic decision-making as discussed in Camerer (2003) and Sanfey et al. (2003).

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Table 1.11. Summary statistics for additional variables. The subscript n represents session and j season.

Variable	Obs	Mean	Std.Dev.	Min	Max
Difference in estimated st.dev. $(\sum_{n=1}^9 St.Dev.^{CP}_{jn} - \sum_{n=1}^9 St.Dev.^{IQ}_{jn})$	2,160	14,186	2,213	8,583	16,350
Advantageous inequality in IQ (observed profit - estimated profit if in IQ and observation > estimation, 0 otherwise), lagged	2,052	1,208	2,328	0	21,537
Disadvantageous inequality in IQ (estimated profit - observed profit if in IQ and estimation > observation, 0 otherwise), lagged	2,052	1,261	2,772	0	30,875
Advantageous inequality in CP (observed profit - estimated profit if in CP and observation > estimation, 0 otherwise), lagged	2,052	122	421	0	4,173
Disadvantageous inequality in CP (estimated profit - observed profit if in CP and estimation > observation, 0 otherwise), lagged	2,052	123	399	0	3,643

Table 1.12. Comparison of Random Effects Logit Models for Choice of IQ. All variables are standardized except for binary variables. In parenthesis are z score.

Model	1		2		3	
	Early seasons	Later seasons	Early seasons	Later seasons	Early season	Later seasons
Competitiveness index subscale 1 (std)	-0.18 (1.23)	-0.36 (2.22)*	-0.18 (1.23)	-0.36 (2.24)*	-0.21 (1.48)	-0.35 (2.17)*
Competitiveness index subscale 2 (std)	0.22 (1.57)	0.04 (0.25)	0.2 (1.45)	0.02 (0.13)	0.21 (1.56)	0.07 (0.47)
Coefficient of CRRA (std)	-0.09 (0.69)	-0.05 (0.37)			-0.08 (0.58)	-0.06 (0.43)
Coefficient of CRRA (std) X Risk seeking and neutral dummy X Dif. in estimated st.dev.			-0.11 (0.61)	-0.1 (0.65)		
Coefficient of CRRA (std) X Risk averse dummy X Dif. in estimated st.dev.			0.01 (0.06)	0.04 (0.3)		
Inequality aversion (std)	-0.28 (2.07)*	-0.24 (1.64)	-0.28 (2.12)*	-0.24 (1.69)		
Inequality aversion (std) X Inequality dummy (1 if 2 and over, 0 otherwise) X Disadvantageous inequality in IQ profit					-0.05 (1.6)	0.06 (1.14)
Inequality aversion (std) X Inequality dummy (1 if 2 and over, 0 otherwise) X Advantageous inequality in IQ profit					-0.01 (0.23)	-0.06 (0.96)
Inequality aversion (std) X Inequality dummy (1 if 2 and over, 0 otherwise) X Disadvantageous inequality in CP profit					-0.57 (2.89)**	-0.47 (1.68)
Inequality aversion (std) X Inequality dummy (1 if 2 and over, 0 otherwise) X Advantageous inequality in CP profit					0.04 (0.18)	0.22 (0.59)
Inequality aversion (std) X Inequality dummy (1 if less than 2, 0 otherwise) X Disadvantageous inequality in IQ profit					0.03 (0.53)	-0.07 (0.77)
Inequality aversion (std) X Inequality dummy (1 if less than 2, 0 otherwise) X Disadvantageous inequality in CP profit					-0.03 (0.52)	-0.39 (1.62)
Inequality aversion (std) X Inequality dummy (1 if less than 2, 0 otherwise) X Advantageous inequality in CP profit					0.48 (1.14)	-2.46 (1.31)
Inequality aversion (std) X Inequality dummy (1 if less than 2, 0 otherwise) X Advantageous inequality in CP profit					-0.43 (0.93)	0.65 (0.61)
ln(The number of other CP choosers excluding oneself), lagged	-0.4 (0.92)	0.42 (0.74)	-0.39 (0.89)	0.39 (0.68)	-0.22 (0.5)	0.21 (0.37)
Binary catch (1 if catching more than IQ, 0 otherwise), lagged	-0.26 (0.98)	-0.27 (0.83)	-0.25 (0.97)	-0.27 (0.84)	-0.36 (1.3)	-0.2 (0.59)
Profit difference (latest experienced profits in IQ - CP)	0.14 (4.66)**	0.31 (8.11)**	0.14 (4.64)**	0.31 (8.03)**	0.15 (4.60)**	0.32 (7.76)**
Constant		0.7 (2.94)**		0.65 (2.64)**		0.66 (2.74)**
Random effects for subjects		0.01 (0.03)		0.01 (0.03)		-0.09 (0.37)
Ln(likelihood)		-907.51		-907.44		-897.31
Wald Chi^2		178.73**		179**		190.01**
Degree of Freedom		14		16		28
Obs		2,033		2,033		2,033
Num of groups		107		107		107

* $p < 0.05$; ** $p < 0.01$

MANUSCRIPT – 2

How Can Community-Based Management Improve An Outcome? The Effects of

Revenue Sharing and Social Capital in a Fishery

In preparation for journal submission

by

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Abstract

We empirically decompose the effects on management outcomes in common-pool resource management into three: the direct effect of management systems, the direct effect of social capital, and the indirect effect of management systems and social capital interacting each other to influence the outcomes. In particular, we focus on revenue sharing arrangement as a possible management tool in a fishery, in which a group of harvesters shares catch and/or revenue among the members of a fishery cooperative. In addition to each of revenue sharing and social capital influencing a fishery independently we hypothesize the synergy between revenue sharing and social capital. Social capital potentially affects the efficiency that revenue sharing brings while revenue sharing can foster social capital, which eventually leads to better management outcomes. An important intermediary between the two factors and the outcomes is collective efforts performed as a group often in a community-managed fishery. This paper provides the first rigorous analysis to measure the effect of revenue sharing and social capital and to identify the mechanism, through which revenue sharing and social capital affect the outcomes of a fishery. We quantified social capital using controlled economic experiments with fisherman subjects as well as surveys. Using the data collected from ten Japanese fishery groups and wild cluster bootstrap for small sample inference, we find evidence of the indirect effect of both revenue sharing and social capital interacting to affect the fishery in information network. . However, we find no robust evidence of the direct effect of revenue sharing improving an outcome in a fishery. The results also show that fishery groups achieving economic success are comprised of fishers with higher general trusting attitudes and fishery groups achieving better stock conditions consists of fishers having similar information network size.

Key words: community-based management, partnership, fishery cooperatives, social capital

JEL: C23, C93, Q22

2.1 Introduction

The importance of community-based management has been long recognized for successful governance of common pool resources (Ostrom, 1990, 2002). Contrary to Hardin's Tragedy of the Commons (1968) or Olson's Logic of Collective Action (1965), empirical research has found many successfully self-governing communities through extensive case study (Baland & Platteau, 1996; Ostrom, 1990; Wade, 1989). This is no exception in fisheries (Pinkerton, 1994). Fishery cooperatives, where fishermen collectively manage the fishery, has been garnering much attention from both regulators and academics as a way to complement and/or supplement existing management systems such as rights-based management (Deacon, 2012; Townsend, Shotton, & Uchida, 2008). In fact, Northeast multispecies groundfish fishery in US has implemented a sector management system, in which voluntarily formed sub-groups of harvesters may manage their collective total share of the harvest as a group right (Pinto da Silva & Kitts, 2006). Thus, understanding how and why fishery cooperatives succeed is not only important but also timely in terms of policy relevance.

Revenue sharing arrangement is a type of management rule in a fishery, in which harvesters share catch and divide equally the resulting revenue among the members of a fishery cooperative, regardless of how much each harvester contributed. Employment of such arrangement is a collective action that a group of harvesters takes. The role of revenue sharing in fisheries management has been examined in the literature (e.g. Gaspart & Seki, 2003; Platteau & Seki, 2001; Uchida & Baba, 2008), but less studied are the quantitative effect of revenue sharing and its mechanism,

through which revenue sharing arrangement attains success. In this paper we hypothesize the interaction between revenue sharing and social capital; revenue sharing augments social capital in a community and among fishers, and social capital also influences various incentives possibly induced under revenue sharing and the efficiency that such arrangement brings.

This paper provides the first rigorous analysis on measuring the direct effects of revenue sharing and social capital in a community-managed fishery, and identifies the indirect effects resulting from the interaction between revenue sharing and social capital. An important intermediary between the two factors, revenue sharing arrangement and social capital, and the outcomes of a fishery is collective efforts defined as any efforts performed as a group to increase harvesting performance of a fishery. The efforts include stock enhancement, rotation of fishing grounds, collective search for schools of fish, exchange of information, and collective use of fishing boats and/or fishing gear. Revenue sharing arrangement and social capital enhance the effect of the collective efforts, which leads to efficient and sustainable use of resources in the long run. Contribution to the group efforts aligns with self-interest when a group of harvesters shares revenue and harvesters are devoted to collective value due to social capital in a community.

Social capital is a concept that attributes such as trust, cooperation, and reciprocity among people, and norms and networks in a community are important in improving economic life (Fukuyama, 1996; Putnam, 2001). Consensus has been established as to importance and influence of social capital in economic analysis (Dasgupta & Serageldin, 2001) although some skepticism as an analytical concept—

how social capital should be incorporated in an economic model—has been expressed (Arrow, 2001; Solow, 2001). In particular, the role of social capital in a community that self-governs a community resource has been highlighted (Ahn & Ostrom, 2008; Bowles & Gintis, 2002; Gutiérrez, Hilborn, & Defeo, 2011; Pretty, 2003). In fact, Carpenter and Seki (2011) showed a strong correlation between fishermen's propensity to cooperate and fishing productivity. Social capital is also found to be empirically associated with economic productivity in other workplace (e.g. Barr & Serneels, 2009; Bouma, Bulte, & van Soest, 2008; Carter & Castillo, 2002; Karlan, 2005; Knack & Keefer, 1997).

Revenue sharing arrangement induces conflicting incentives within a fisher: free-riding on others' fishing effort and maximizing collective value (Kandel & Lazear, 1992). Theoretically free-riding on other's fishing efforts dominates one's incentive in a sufficiently large organization because marginal return from free-riding is usually greater than its cost. However, shirking behaviors (to become lazy by sharing revenue and not exert excessive effort) in a commons tragedy situation can increase efficiency. As to why revenue sharing arrangement may not induce disproportionate shirking, Gaspart & Seki (2003) attributed to status seeking among fishermen, which counteracted against excessive shirking in fishing effort. Heintzelman et al. (2009) balanced an individual incentive to free ride in own effort and intra-group competition, which prevented excess harvesting and increased efficiency.

Empirical findings identified the important roles of the collective efforts in revenue sharing groups. The collective efforts are a source of efficiency that can be

brought by revenue sharing because they are expected to generate synergies, which is key in a partnership structure such as revenue sharing arrangement (Sherstyuk, 1998). By aligning self-interest with a group interest revenue sharing supports an incentive to contribute to the collective efforts, which bring synergies and lead to successful management of a fishery. Platteau and Seki (2001) emphasized importance of the collective efforts such as synchronization of fishing effort, collective net repair, and exchange of information in Japanese grass-shrimp fishery with revenue sharing. Another revenue sharing group in Japanese small pink shrimp fishery identified joint marketing and harvest control as a significant motive of sharing revenue as well as major contribution to increased efficiency (Uchida & Baba, 2008).

Social capital can sustain individual fishers' contribution to the collective efforts. Assuming that all fishery groups engage in some form of the collective efforts, how much time and effort each group and each individual within a group put for these collective efforts can vary. Among many aspects of social capital the focus in this paper is on cooperation, trust, and information network. Cooperative relationships fishers have in a fishery group can make a difference in the level of contribution because fishers can be inherently cooperative to each other or can be more cooperative knowing that other fishers are also cooperative. Similarly general trusting nature of fishers can affect the level of contribution because they may trust others for contributing as well. Having greater information networks in a community in density and in scale may also increase the level of contribution because fishers may know each other's harvesting behaviors, which may enable them to contribute in such a way that the benefits from contributing can accrue to themselves.

Importance of social capital and more broadly immaterial motivation in economic decision-making has been stressed in the literature, especially in behavioral economics. Behavioral response to monetary incentives sometimes does not align with regulator's intention as referred as crowding out (Cardenas et al., 2000). In the worst case economic incentives may undermine individual voluntary motivation to contribute to a better world (Carlsson & Johansson-Stenman, 2012). These studies suggest that immaterial incentives, in addition to economic factors such as production technology as shown in Kaya and Vereshchagina (2014), can play an important role in ensuring success of revenue sharing. For example, each harvester may contribute to the collective efforts rather than free-ride because of moral or reputation among fishers, which has been shown to overcome moral hazard (e.g. Bénabou & Tirole, 2006; Brekke et al., 2003; Gaspart & Seki, 2003). Trust or reciprocity among members, or social norms can support individual motivation to make sincere commitment to a group interest.

Not only do these two factors, revenue sharing and social capital, support an incentive to contribute to the collective efforts separately, but also through the interaction with social capital revenue sharing further enhances the effect of the collective efforts, and through the interaction with revenue sharing social capital strengthens a team for the collective efforts. The collective efforts motivated by revenue sharing and social capital bring synergies in fishing, which reinforces the indirect effect of both of revenue sharing and social capital. In other words, greater social capital among fishers financially bound by revenue sharing can strengthen the effect of the collective efforts, which generates the indirect effect of revenue sharing

and social capital. For example, revenue sharing fishers can be encouraged to share more information on hot-spots to increase the productivity of fishing as a group. Fishery groups may collectively decide to remove predators for a targeting species; fishery groups with more cooperative fishers may spend more time for this collective task and they may do so more likely if they share revenue. Fishery groups with higher levels of general trust may collectively repair fishing gears more often without revenue sharing arrangement, but with revenue arrangement and trusting nature of fishers fishery groups may even collectively use fishing gear let alone repair them. In all these examples revenue sharing and social capital can directly affect the outcomes in a fishery but also they can influence them indirectly by enhancing the effect of each other.

This paper formally tests the effect of revenue sharing and social capital separately on the four measurements of the outcomes in a fishery: ex-vessel price per kilogram (economic outcome), resource stock density measured per squared meter (biological outcome), economic success perceived by fishers, and resource conditions perceived by fishers. In addition, this paper also tests the pathway, through which revenue sharing and social capital interact each other to affect the outcomes indirectly. Together this paper provides the first rigorous analysis to measure the effects of different management systems and different levels of social capital in a community-managed fishery and to identify how economic systems and social aspects of a community affect the outcomes of a fishery. The collective efforts performed as a group in a fishery mediates between the outcomes in a fishery and the two factors, revenue sharing arrangement and social capital.

Utilizing both numeric data and perceived scales for measurement of the outcomes this paper achieves comprehensive analysis of management outcomes. The data were collected in Japan, which is one of the countries that have a long history of community-based fisheries management (Yamamoto, 1995) as well as ample cases of revenue sharing. Many Japanese fisheries operating under revenue sharing have been successfully managing the resources as well as generating resource rents (Carpenter & Seki, 2011; Platteau & Seki, 2001; Uchida & Baba, 2008). To quantify cooperation controlled economic experiments with fisherman subjects were conducted. As for trust and information network indices are constructed from survey responses of the same fisherman subjects. Using wild cluster bootstrapped p-values for small sample inference, we rigorously quantify the effect of revenue sharing and social capital in a reduced form. In addition, we explore the mechanism, through which those factors interact with each other and affect the outcomes in a fishery.

2.2. Conceptual Framework

A fishery possesses various externalities inflicted by individual harvesting decisions. Theoretical studies incorporated them as stock and crowding externalities, and demonstrated how these externalities can cause rent dissipation in fisheries (e.g. Clark, 1980; Smith, 1969). In a static common pool resource environment, equilibrium is achieved where average revenue from exploitation equals to its average cost because a harvester can establish the right over the resource only by exploiting it (common property externality) (Walker, Gardner, & Ostrom, 1990). In a dynamic fishery environment, spatial, contemporaneous, and temporal production externalities need to

be incorporated (Clark, 1980; Homans & Wilen, 2005; Smith, 1969). Harvesting adult fish in the current period can alter reproductive ability of the fish population for the following year while harvesting young fish may not be profitable (stock externality). Heterogeneous returns to effort across fishing locations may drive harvesters to fish more in some locations than others, but harvesters do not consider the cost of their participation in a particular location to others when choosing their fishing site (crowding externality). Similarly, the return to effort at a particular time may vary depending on the total amount of output produced at that time (contemporaneous externality) (Anderson & Uchida, 2014; Huang & Smith, 2014; Scheld, Anderson, & Uchida, 2012).

There is no single all-round remedy that can solve the externalities in fisheries all at once. A catch share system or an individual transferable quota (ITQ), spreading over the US fisheries as a promising management tool, has been shown that it can fully internalize the common property externality by setting the price of a quota at shadow value of a fishery (Arnason, 1990; Danielsson, 2000; Grafton, 1996). It is uncertain, however, how ITQs can address the other types of externalities (Boyce, 1992; Copes, 1986).

Revenue sharing arrangement in this study features a group of harvesters who share revenue equally regardless of how much each harvester contributes but not the costs of fishing operations including the cost of the collective efforts (Gaspart & Seki, 2003). This arrangement is different from a sole owner-like arrangement as in the one implemented in Chignik Salmon Cooperative (Knapp, 2008). Thus, the arrangement itself does not guarantee social optimum. The assumption that individual harvesters

incur costs of fishing operations is consistent with many Japanese fisheries under revenue sharing, and it will be relevant and realistic to other fisheries. Fishermen will start sharing revenue with others with a fishing boat and gear of a different size, horsepower, and age, and thus different fuel efficiency. This difference may continue to exist even after implementation of revenue sharing because of the other fisheries that the members engage separately.

Harvesters' incentives under revenue sharing arrangement can be different from open-access fisheries in three ways. First, the common-property externality can be overcome because individual harvesters are no longer motivated to rush to fish to claim the right to own the fish; all the landings in a fishery regardless of who caught them are pooled across all the members. Second, the stock externality can be mitigated. Individual and thus aggregate fishing effort under revenue sharing is less than when in open-access fisheries because the marginal cost per unit of effort under revenue sharing is N (= the number of members) times greater than an open-access fishery. Third, the crowding or spatial externality can be internalized to some degree because the productivity of fishing as a group is relevant under revenue sharing, not an individual performance. A revenue sharing harvester exerts his effort in such a way to maximize the marginal productivity of all the members because an individual harvester can maximize his profits by increasing group productivity given the number of harvesters. The same logic applies to temporal externality, in which different prices are expected depending on the timing of landing. What is important for a revenue sharing harvester is collective performance, whether temporal or spatial.

2.3 Japanese surf clam fishing in Hokkaido Prefecture

Any entities that conduct commercial fishing in Japan's coastal waters must belong to a local Fishery Cooperative Association (FCA). These FCAs not only enforce national and prefectural regulations but also self-regulate the resources tailored to local conditions. Within an FCA many groups of fishers are formed mainly based on the species they target and/or the fishing gear they use. Each group has their own rules of regulation and management and can decide whether to share revenue. No member can fish independently; every member must operate as a member of the group.

Fishers in Japan do not employ revenue sharing arrangement as insurance against risk of income fluctuations; most of the FCAs in Japan provide their members formal insurance partly subsidized by the national government, which assures no reason for any fishers in Japan to pool revenue as a risk hedge. Platteau and Seki (2001) presented anecdotal evidence for this argument based on the interview conducted with fishermen under revenue sharing arrangement.

Based on the data provided by Uchida and Wilen (2007), many of the revenue-sharing groups are concentrated in the northeastern Japan, target sedentary species, and use small-scale trawl or gillnets. The coastal fisheries in southern Japan are characterized with fishing many species with the same fishing technology, which complicates the process to share revenue. Many sedentary species fisheries are required to employ small-scale trawl and gillnets by regulation, which results in relatively smaller heterogeneity in fishing skills and outcomes compared to other migratory species or other fishing technology such as fishing bonito. According to Fishery Census of Japan, the fishing groups that share revenue accounted for 11

percent of all groups in 1988 and the percentage increased to 17 percent until 1998 until consistent data are available.¹

There are several reasons for choosing Japanese/Sakhalin surf clam (*Pseudocardium sachalinensis*) fishery, known as Hokkigai in Hokkaido Prefecture, for this study. A sufficient number of groups engage in this fishery in the same Hokkaido Prefecture. These groups have adequate variation in with or without revenue sharing while relatively homogeneous in other operational rules including engagement of the collective efforts. Focusing on a particular region and carefully selecting groups based on the preliminary data, but without consulting the outcomes, enables us to control many observed and possibly unobserved characteristics at the time of sampling.

Harvesting technology is one factor controlled at the time of sampling. Both simple and advanced technologies are found in Hokkaido: dredges, jet dredges, spearfishing,² and digging. Jet dredges are by far the most common and the most advanced technology for harvesting the surf clams. This technology was introduced to some FCAs as early as in 1970s in Hokkaido and has gradually spread all over Hokkaido. It is known to mitigate the damages to shells. Employment of this technology is often accompanied by a great reduction in the number of active boats because of its high initial costs.

The Hokkaido government requires their FCAs using the jet dredges to impose a minimum catch size of 7.5 cm and closure of fisheries for certain months during the

¹ In 2003 the ratio of revenue sharing among all groups dropped to 12 percent partly because the definition of fishing groups was changed. In later censuses no comparable information has been provided.

² There are five fishery groups in Hokkaido that spearfish the clams as of 2013. Spearfishing the clams involves spears with craws at the tip to pick up the clams.

spawning season. In addition, many FCAs in Hokkaido self-impose voluntary Total Allowable Catch (TAC) restriction,³ landing volume control, and stock enhancement. Individual skippers are required to cooperate for self-regulation including the collective efforts for stock enhancement.

The way the FCAs in Hokkaido organize their shellfish fishery is practically identical. It involves (1) stock assessment conducted by the staff members at Fisheries Extension Offices located all over coastal Hokkaido in collaboration with local skippers and FCAs, either prior to or after every fishing season; (2) all skippers are called to gather for a pre-season meeting to hear the results of the stock assessment from the local Fisheries Extension Office, to decide a seasonal TAC, and to review operational rules and policy for the season; and (3) during the season a leader and sub-leaders closely watch the market prices (mostly by directly talking with the middlemen) and decide whether to go fishing on the day and if so how much to land subject to the seasonal TAC. Each group usually has an elected leader and multiple sub-leaders for the groups of a significant size.⁴ Finally, (4) during and/or after the season whether they share revenue or not all skippers in all FCAs are required to contribute to the collective efforts to make the fishery favorable for growth of the Japanese surf clams although how much to contribute can vary across the FCAs. These efforts include cultivating ocean beds, removing predators, and transplanting

³ As far as fishermen and FCAs can remember the Japanese surf clam fishery has been enforcing self-imposed TAC, which can range from a few to 20 percent of total estimated stock. According to personal communication with Professor Izumi Sakurai who was a former scientist at Hokkaido Central Fisheries Experimental Station recommended ten percent of a TAC as it was a natural increase of the Japanese surf clams (Sakurai, 2014).

⁴ Individual skippers can decide whether or not to fish on the day the leader decides to go fishing, but they cannot go fishing when the leader decides not to go. On the other hand, when a group shares revenue, skippers must follow a leader's decision; all skippers fish or do not fish altogether.

clams.⁵ Many FCAs also buy juvenile clams from the other fishery groups and release them in their waters.

The surf clam prices do not fluctuate as other migratory species and leaders in any fishery groups have a very good understanding of how much to harvest to maintain the prices. Regardless of the management systems the groups set daily volume restriction in addition to a seasonal TAC. In some groups without revenue sharing arrangement the daily volume restriction can be pre-determined at the beginning of the season, in which case a leader only decides whether to open up the fishery on that day. In all revenue sharing groups and the other non-revenue sharing groups a leader decides how much to land on each fishing day, paying attention to the market prices.

The prices not only depend on supply and demand, but also they can vary with shell colors and sizes. The markets generally give higher prices per kilogram for larger sizes. They also value black shells more than brown shells for their beauty although they are an identical species and should taste the same.⁶ Difference in colors results

⁵ It is believed in some fishermen and FCAs that it creates a better environment for the Japanese surf clams to stir at the bottom of oceans. In fact it can make the ocean beds softer and thus easier for the clams to dig and go deeper in the ocean ground, which turns their shells more black (Sakurai, 2014). Yet, how successful this effort is in making the ocean beds softer depends on geographical conditions and can be minimal in some places. Transplanting is a more direct way to improve growth of the surf clams. High density of the clam population is one of the factors that can limit their growth (Sakurai, 2014).

⁶ In 2012, the FCA E in the Table 2.1 received the average premium of 22 percent for black shells. The FCA E landed black shells and brown shells at different months. The months when black shells were landed received on average lower prices at the overall market in Hokkaido. Thus, 22 percent premium may not be true, and yet it can be confidently inferred that fishermen received at least considerable premium on black shells in 2012. Interviews with fishermen in all FCAs reveal that fishermen are aware of this premium.

from the characteristics of habitats, muddy or sandy, and a choice of the habitats is partly correlated with age.⁷

This market structure of the clams makes the collective efforts for stock enhancement even more important. Stock enhancement can take a form of directly stocking seeds of clams purchased from other FCAs or transplanting younger clams to be harvested in few years later within the same FCA. The purpose and effect of transplanting can be multifaceted; it can simply save traveling time by transporting all at once from distant fishing grounds to the ones closer to the port; it can increase marginal productivity of a fishery by transplanting from densely populated patches to less populated patches; and it can increase marginal revenue of a fishery by changing a composition of black and brown shells. Different types of ocean grounds, specifically whether sandy gravel or mud, create the two colors of the shells. In some FCAs, in which the fishery is composed of different types of ocean grounds, transplanting the clams from sandy sea floor to muddy one can increase value of the clams by turning their shells black.

What fishermen can do to catch higher valued clams is to choose a fishing ground with more abundance in larger, black-shelled clams. This can create a race to fish for larger, black-shelled clams even when a daily quota in addition to a seasonal one is imposed. The survey responses by fishermen reveal importance of location choice in the surf clam fishery. The important information that fishermen most

⁷ Shell colors of the Japanese surf clams result from their natural habitats; muddy sediments turn their shells black while sandy and gravel sediments keep them brown. The ocean grounds on the Pacific Ocean side are muddier whereas the Sea of Japan side tend to have a characteristic of rocky, sandy sediments (Sakurai, 2014). Difference in the market values by color is particularly important in the sampled fishery groups because all of them are on the Pacific Ocean side.

exchanged with the other fishermen during the 2012 season was about specific hot-spots.

Well-managed groups can maintain higher prices per kilogram in the long run by coordinating harvesting strategies in accordance to the transplanting effort.

Location choice in harvesting strategies becomes even more important when the collective efforts for stock enhancement are in place. The cost of stock enhancement needs to be incorporated in a fisher's decision making in selecting a specific fishing location in order to maximize social benefits as a group. For instance, harvesting the clams before their shells turn black ruins the transplanting effort. Thus, harvesting in coordination with the transplanting effort in addition to choosing a location with highest marginal revenue is important.

While social capital can unite fishers and incline them for a group interest without financially binding them, revenue sharing arrangement can provide a financial incentive for collective fishing (Platteau & Seki, 2001). The fishers under revenue sharing are financially motivated to coordinate effort allocation; the non-revenue sharing fishers do not have such an incentive because their profits solely depend on their own catch and the benefits of effort allocation may not accrue to all the fishers equally. All fishers, regardless of management systems, depart from their ports at the sunrise (regulation set by the government), but only revenue sharing fishers return to the ports all together at the same time. Some revenue sharing fishers designate themselves to specific fishing grounds prior to departure and communicate over the radio on the sea about who catch how much in where, further adjusting effort allocation on the sea.

In addition, the degree of effort coordination and devotion to the collective efforts can vary within revenue sharing groups and difference within the revenue-sharing groups may be attributable to different levels of social capital. Some groups may allocate the efforts roughly (e.g. designate areas for fishing) while others may coordinate with a great precision (e.g. designate a boat to a specific fishing location), which can make a difference in the outcomes even among the same revenue sharing groups. Similarly, some revenue-sharing groups may devote more to the collective efforts than other revenue-sharing groups. The more fishers contribute to the efforts the greater the effect per unit of effort can be to the point where the effect of these collective efforts exhibits increasing returns to scale. For example, transplanting a negligible amount of the clams may fail to bring the density of the clams down to the level desired for their growth although the ones transplanted can benefit.

How revenue sharing can affect the resource conditions can appear in deciding a self-imposed TAC and how strictly a group enforces the TAC, which is voluntarily set and not required by the bylaws to be a specific amount or in a specific range. All sampled fishery groups in this study have been conducting stock assessment for the entire sampling period. The results of the stock assessment have been used to assist the FCAs and the fishermen to determine a seasonal TAC for the coming season.

Revenue sharing arrangement and social capital can also affect the resource stock through the collective efforts. Directly stocking seeds of the clams can increase the stock size; transplanting can enhance growth of the clams; removing predators can help more clams to survive and live longer. The effects of all these collective efforts can be closely related to an incentive under revenue sharing and the level of social

capital as discussed above. The stock assessment reports also provide detailed information on density and age composition of the clams for each fishing plot. This is not the only source of information fishers can have (fishers know about the fishing grounds from their fishing experience) but is certainly helpful to plan stock enhancement and effort coordination.

Our hypotheses can be rephrased in the specific context of this Japanese surf clam fishery in Hokkaido. The first hypothesis is that revenue sharing arrangement improves ex-vessel prices as well as perceived income and conserves the resource stock better through coordinating the fishing efforts and the collective efforts for the stock enhancement more efficiently (Figure 2.1). The second hypothesis is that social capital—cooperation, trust, and information network—improves the same outcomes through uniting fishers without any economic incentives. These are the direct effects of the two factors. The third hypothesis is that the interactions between revenue sharing and social capital lead to better outcomes. The hypothesis can be divided into three sub-hypotheses for each social capital element to be examined. The first sub-hypothesis is that revenue sharing fosters cooperation among fishers and the cooperation augmented by revenue sharing further reinforces coordination in a fishery and results in improvements in the outcomes. The second sub-hypothesis is that general trusting attitudes in a community lead to revenue sharing, which further assures coordination in fishing and better outcomes. The third sub-hypothesis is that revenue sharing develops information sharing networks among fishers, which affects efficiency of coordination in a fishery and improves the outcomes. The differences in

the causal directions in the three sub-hypotheses will become more plausible when exact definitions of each parameter are introduced below.

2.4 Methods

Sampled Groups

Parallel to pre-processing in large-N studies (Ho et al., 2007), carefully selecting cases at the time of sampling is crucial in small-N studies so as to remove any relevant factors that can take away the degree of freedom in regression (George & Bennett, 2005; King, Keohane, & Verba, 2001). Thus, sampled fishery groups were selected based on the observed characteristics. The data from Uchida and Wilen (2007) contained such information as of 2005 for 91 fishery groups in Japan, 53 of which operated under revenue sharing arrangement. In addition, the data provided location of a fishery, a year established, a type of fishing technology, a type of self-regulation, and a type of collective fishing efforts.

The sample consists of ten fishery groups, five of which are under revenue sharing and the other five are not and have never been under such arrangement. They all engage in a small-scale trawl fishery, targeting the Japanese surf clams⁸ and are located in Hokkaido prefecture (eight of them are in Kushiro/Nemuro region, eastern Hokkaido), which means facing the same market, biological conditions, and historical backgrounds. All the groups self-manage the resources of the Japanese surf clams as

⁸ Fishers can incidentally catch other shellfish species such as Northern great tellins (*Megangulus venulosus*) and sunray surf clams (*Macra chinensis*). Although in some FCAs the value of these bycatch shellfish can weigh more than the Japanese surf clams, importance of those bycatch species in the fishery groups in this study is not greater than 30 percent of all the landings, and it is safe to say that fishers in this study target the Japanese surf clams.

detailed above. The groups are only different in a decision to employ revenue sharing arrangement accompanied by collective fishing operation in major characteristics and management/operational rules, but the degree of self-regulation can also differ across the FCAs (Table 2.1).

The sampling distribution of the ten groups can approximate the population distribution of small-scale trawl fisheries targeting the Japanese surf clams. First, the Hokkaido prefecture accounts for 76 percent of the Japanese surf clam landings in Japan, making it by far the biggest producer as of 2006.⁹ Second, the sampled ten surf clam groups are a typical surf clam fishery in Hokkaido. As of 2011, 70 percent of the surf clam groups in Hokkaido employ jet dredges, which are the technology all the sampled fishery groups have been using for many years.¹⁰ Among them the sampled groups account for about 30 percent of total catch volume and value in Hokkaido. The average value of all the surf clam fishery groups using the jet dredges was 37.39 million yen in 2011 while the average value of the sampled groups was 58.40 million yen. These two distributions are statistically significantly different (Mann-Whitney-Wilcoxon test). However, after excluding the groups that were worth less than 10 million yen the sampling distribution is not statistically different at a conventional level from the population distribution in terms of catch value, catch volume, and the number of skippers (Mann-Whitney-Wilcoxon test). Thus, the results from analyzing

⁹ Since 2007 the fishery census has only reported combined value of the Japanese surf clams with other shellfish.

¹⁰ According to the data collected by Hokkaido Fisheries Extension Offices, 54 out of 77 groups employed the jet dredges as of 2011. After excluding the biggest producer, Tomakomai FCA, the sampled fishery groups produce 40 percent of the surf clams by value and volume. We intentionally avoid including the Tomakomai FCA in the sample because, in addition to being the biggest producer, the Tomakomai city also promotes the surf clams as a symbol of the city and the surf clams from the FCA seems to have some branding power at the market, which is not the effect we intend to capture in this study.

the sampled groups can be inferred to the other surf clam fishery groups that have some importance in value.

Data

We collected this unique dataset containing group information from the ten fishery groups in a panel format from 1990 to 2012 and individual information on 79 skippers belonging to the ten groups in a cross-sectional format. Our outcome variables are measured at a group level as well as an individual level. For the group outcome variables our data are in a panel format, and we regress the outcomes on group management decisions and group social capital parameters. For the individual outcome variables our data are in a cross-sectional format, and we regress the outcomes on group management decisions and individual social capital parameters. In what follows we describe construction of four outcome variables—two at a group level and two at an individual level—followed by social capital parameters.

We approximate the group economic outcome in a fishery with yearly average ex-vessel prices per kilogram with shell-on.¹¹ Thus, fishermen's profit maximization is approximated as revenue maximization by catching higher valued clams. Catch volume is not a good indicator of management in this fishery because all the groups self-impose a TAC in consideration for their resource conditions. The other important aspect of fishery management is the biological outcome in a fishery, which is approximated with resource stock density measured as volume in grams per squared meters of fishing grounds.

¹¹ The prices in this study are the average prices of the group, that is, yearly total value divided by yearly total landings.

In addition to these numerical measures for the group outcomes, fishers' subjective perceptions towards management outcomes will be used to further understand the effects of management systems. These individual outcome variables are constructed from the survey responses; one question deals with an environmental outcome of fishery management while the other question addresses economic performance of fishery management. Specifically these questions are "Resource management in your FCA is successful in increasing and/or maintaining shellfish resources" and "Fishery management in your FCA is successful in increasing and/or maintaining profits from shellfish fishing" respectively. The fishermen responded on a five-point Likert scale from 1: strongly disagree to 5: strongly agree. Summary statistics of the responses to the two questions are presented in Table 2.2.

The variables for perceptions towards the outcomes and social capital were collected by the survey and the experiment with individual skippers. The social capital parameters are cross-sectional data measured in either 2013 or 2014, and are aggregated to the group level and assumed to be constant over time when they are regressed on the ex-vessel prices and resource stock density in a panel format, which were collected at a group level along with other fishing operation data. The prices and stock information are time-series cross-sectional data from 1990 to 2012 with some random missing observations in early years, except for two observations of one group that voluntarily closed the fishery for two years because of concern for the resource. Table 2.3 shows summary statistics of the two group outcome variables.

Two of the five revenue sharing groups switched from non-revenue sharing to revenue sharing during the period of the panel analysis. All other groups have been

under the same management systems. In addition, all the groups have been performing other relevant fishing practices such as stock assessment, a TAC, and transplanting/stocking for the entire period.

Controlled economic experiments with fishermen subjects were conducted from fall 2013 to spring 2014. Participants also completed a survey for demographics and answered questions on perceptions towards management outcomes, trusting attitudes, and information network among fishermen such as the number of other fishermen they exchange information with. Table 2.4 shows summary statistics of participants. One to 16 skippers, ranging from 15 to 100 percent of all member skippers, participated in a session. An average skipper in the sample has been in the surf clam fishery for 24 years as far as the panel analysis covers.

In addition, demographic difference between revenue sharing groups and non-revenue sharing groups is significant in age and household size (both p value < 0.05 , Mann-Whitney-Wilcoxon test). Revenue sharing skippers in the sample are significantly younger and have a greater household than those who do not share revenue. But we did not find a significant difference in shellfish fishing experience, possibly one of the most important factors that can affect social capital.

Cooperation parameters

Although social capital involves various attributes, the focus in this study is on cooperation measured by controlled economic experiments and trust and information network measured by the survey. The parameters for cooperation are estimated from the observations of the Voluntary Contribution Mechanism (VCM). The indices for

trust and information network are constructed from the survey responses. They are then aggregated into group variables as mean and standard deviation of group members, which are used in main regression to measure their effects on the outcomes.

To measure cooperation among fishermen the standard, repeated VCM was conducted (Camerer & Fehr, 2004; Carpenter, 2002). Participants were recruited through the FCAs, and many of them held some executive positions in the fishery groups at the time of recruitment. A flyer was provided with the FCAs to make general calls for the experiments and the surveys, and the flyer indicated that the volunteers would be asked to participate in economic experiment (play a simple game) in addition to a survey on fishing operation and they would be paid in cash fixed participation fees plus the earnings from the experiment.

Before the experiment begins participants were randomly divided into groups of four persons that were sustained for an entire session. The participants were not told whom they were playing with.¹² The participants were given 3,000 yen (roughly US\$30) worth of coins as an endowment every round and asked how much to contribute to a public good from his endowment. Once all the participants made their decision the total contribution of each group was calculated, doubled by the experimenter, and then distributed equally among the group members. The amount not contributed to a public good was kept to each participant. The participants earn a sum of the dividends from a public good, regardless of their own contribution to a public good, and the money kept to themselves for a round. The dominant strategy in the game is to contribute nothing because marginal return from a public good is smaller

¹² In case that the number of participants was not multiple of four, which happened at most sessions, the contribution amounts of some participants were counted twice in multiple groups to avoid the effect of varying group size as in Carpenter and Williams (2010).

than the one from a private account regardless of total group contribution. The game was repeated ten times with the exception of one session.¹³ At the end of the experiment two of the ten rounds were randomly drawn as a binding round, and the participants were paid the average of the payoffs from the two rounds plus a participation fee of 3,000 yen.¹⁴

A total of 80 subjects participated in the experiment; two subjects were excluded from the analysis.¹⁵ All the sessions took place at a conference room at the FCA or at the community center nearby. The participants were seated facing the wall, and in between the participants portable blinds were constructed (Figure 2.2). At the beginning of every round the participants were given three boxes in different colors. In a yellow box were 3000 yen worth of coins—real money—as an endowment, a red box was intended for a private account, and a green box was for public good contribution. The participants were asked to move all the coins from the yellow box to either the red box (to keep) or the green box (to contribute), which made it difficult to guess what other participants were doing based on the amount of the noise made from

¹³ The last five rounds were conducted with social disapproval treatment introduced by Carpenter and Seki (2011). However, in this study we do not consider the parameters obtained by this treatment although the observations during these rounds are used for estimation. The session at one FCA repeated the standard VCM for six times with another version of social disapproval for the last two rounds.

¹⁴ A participation fee was set high in this experiment to mitigate concern expressed by many FCA staffs for performance-based payment. The session accommodated two more games for different research and thus lasted in total between 2.5 hours and 3 hours. The VCM lasted less than 1.5 hours and the average earning from this game was 4,700 yen.

¹⁵ One subject was a FCA staff and did not face the same incentive as other subjects. He did not expect to receive any compensation during the experiment and planned to surrender it to his supervisor. He was needed in the session because only four fishers showed up, which would identify exactly whom they were playing the game with. Difference in the degree of anonymity potentially alters the incentives because the participants know each other. The other subject was an elderly skipper who contributed all of his endowment throughout the session. At the end of the session he gave his earnings to his grandson who worked at the FCA. It is apparent that he did not take a series of decisions seriously. The average contribution made by the other three members in the group with the FCA staff was smaller than the rest of the participants and the average contribution in the group with the elderly skipper was greater, and these two groups (excluding the FCA staff and the skipper) are significantly different from the rest of the participants at p value < 0.01 respectively.

moving coins. Once the decision was made the experimenters collected all the boxes and calculated the total contribution of each group and the dividends from a public good. These results were written down on a sheet of paper and distributed to the participants with the three boxes and the coins for the next round.

The mean contribution of all participants is 1,635 yen (55% of endowment) with individual contribution ranging from zero to 3,000 yen (0-100% of endowment). Revenue sharing fishers on average contributed 1,600 yen (53%) to a public good, compared with the average non-revenue sharing fisher contributing 1,762 yen (59%). The difference is statistically significant at p value = 0.004 (Mann-Whitney-Wilcoxon test). For comparison the same experiment by Carpenter and Seki (2011) with fisherman subjects yielded the overall average contribution of 49% ($N = 27$) with revenue sharing fishers contributing 51% and non-revenue sharing fishers contributing 46%. This suggests that the fishermen in our study contributed slightly more overall regardless of management systems and the difference in contribution between revenue sharing fishers and non-revenue sharing fishers went in the opposite direction. However, this does not necessarily imply that revenue sharing fishers in this study cooperate less because they are statistically significantly younger than non-revenue sharing fishers, which is a very important demographic characteristic that can affect how much to contribute (Aswani, Gurney, Mulville, Matera, & Gurven, 2013). In fact, significant difference between the two groups disappears after controlling for age.¹⁶

¹⁶ The OLS without controlling for age ($\text{Contribute}_{ijt} = \alpha + \text{Rev.Sharing}_j + e_{ijt}$; Adjusted R^2 for the model is 0.009) implies that revenue sharing skippers contribute on average 202 yen less than the average non-revenue sharing skipper at p value=0.006 while the OLS controlling for age ($\text{Contribute}_{ijt} = \alpha + \text{Rev.Sharing}_j + \text{age}_i + e_{ijt}$; Adjusted R^2 for the model is 0.040) does not find significant difference between the two groups (p value=0.204). Multilevel modeling incorporating random effects of individuals nested within sessions also yields similar results; revenue sharing is not a significant factor (p value=0.431) when age is controlled for (Wald statistics for the model is 6.73).

The observed amount contributed to a public good, y , is censored between zero and 3,000 and is related to a latent variable, y^* , as follows.

$$y_{ijt} = \begin{cases} 0 & \text{if } y_{ijt}^* \leq 0 \\ y_{ijt}^* & \text{if } 0 < y_{ijt}^* < 3000. \\ 3000 & \text{if } y_{ijt}^* \geq 3000 \end{cases}$$

The amount contributed to a public good, y , is regressed on a sum of contribution made by other members in the previous round, $\mathbf{X}_{-ij(t-1)}$. The model needs to allow individual variation for this coefficient for the reason to be apparent later and thus accommodates a random parameter for $\mathbf{X}_{-ij(t-1)}$. In addition, it is likely to be correlated within the same subject nested within the same session and thus the two random effects for subjects and for sessions are also estimated.

We estimated this model using Generalized Latent Variable Model (Skrondal & Rabe-Hesketh, 2004). This model is very flexible that it estimates multi-level random effects as well as one random parameter while allowing the Tobit specification simultaneously. The model is estimated with the following specification.

$$\Gamma\{E(y_{ijt}^*|\mathbf{X}, \mathbf{u})\} = \beta_0 + \beta_1 \mathbf{X}_{-ij(t-1)} + u_j^1 + u_{ij}^2 + u_{ij}^3 \mathbf{X}_{-ij(t-1)},$$

where β_0 and β_1 are parameters to be estimated, $\mathbf{X}_{-ij(t-1)}$ is a vector of a sum of contribution made by other members in the previous round, u_j^1 and u_{ij}^1 are random effects for sessions and subjects, u_{ij}^3 is a random parameter, $\Gamma(\cdot)$ is a link function (the identity or the probit function), and y_{ijt}^* is distributed as Gaussian or Bernoulli. We assume

$$E(y_{ijt}^*|\mathbf{u}) = \Gamma^{-1}(\beta_0 + \beta_1 \mathbf{X}_{-ij(t-1)} + u_j^1 + u_{ij}^2 + u_{ij}^3 \mathbf{X}_{-ij(t-1)}).$$

Table 2.5 shows estimation results of the model. An average participant contributes 1,272 yen and an individual variation is in a range of 998 yen standard deviation, which is both economically and statistically significant. An average participant contributes 0.06 yen (the average marginal effect on the observed distribution) more to a public good after observing a marginal increase in the contribution by the other members, which is statistically significant but not economically significant. This varies across individuals in a 0.08 yen standard deviation at a statistically insignificant level.

The results suggest that the participants care about what the others' contribution is and do respond to it cooperatively. The positive coefficient for β_1 implies that they do not shirk and cooperate more when the others cooperate more. However, a dominant part of their strategies is their own contribution level determined outside of what the others did in the previous round. The participants are a group of people who interact daily or at least regularly in a fishery regardless of management systems. It is possible that they decide their contribution based on the relationship they have in a daily life rather than on what the other participants did in this experiment. This is captured in β_0 and its variation across individuals as u_{ij}^2 .

The two parameters for cooperation are created: conditional cooperation and unconditional cooperation (Carpenter & Williams, 2010; Carpenter & Seki, 2011). The conditional cooperation parameter takes a value of u_{ij}^3 and measures how cooperative a person is in response to observed cooperativeness of the other members. A greater value of this parameter indicates that a person is willing to cooperate more after knowing the others' cooperation than an average subject in the sample. The

unconditional cooperation parameter takes a value of u_{ij}^2 and measures general cooperativeness of a person after taking into account conditional cooperation. The greater the value of this parameter, the more cooperative a person is independently from what the others are doing. Table 2.6 shows summary statistics of the two parameters, which are normally distributed by assumption.

Information network indices

Based on the work by Holland et al. (2010) and Holland et al. (2013) we constructed the measures of information network a skipper has in the shellfish fishery (Table 2.7). The size of information network is constructed by the survey responses to the question asking the number of shellfish fishermen with whom to share important information that potentially affected own profits from shellfish fishing during the fishing season in 2012. An average skipper in these fishery groups shared such information with ten skippers. Normalizing the size by the possible number of relationships (the size of a fishery group) yields density of information network. An average density was about 30 percent, ranging from 0 to 100 percent. This indicates, for example, in the case of the fishery group comprised of ten fishermen an average fisherman would have shared important information with three other fishermen.

After listing five names of fishermen with whom a person has most important relationships subjects were asked what kinds of information he shared with each of the relationships.¹⁷ Based on the information provided by FCA staffs six kinds of information were identified as relevant to the surf clam fishery: market, buyer

¹⁷ Some skippers refused to provide the names of other skippers because they feel that they would leak personal information of others, which resulted in a lower response rate for the subsequent questions on varieties of information and frequency of sharing the information than the other questions.

information, specific hot-spots, market for bycatch and its hot-spots, high gear density areas, and boat and gear. Taking the average of the number of kinds of information a person shared with the listed relationships produces an index for varieties of information. An average skipper shared about two types of information. Among the six kinds the information on specific hot-spots was shared most (61% of the relationships), followed by market information (56%). This suggests that decisions of where to fish are one of the most important drivers in a successful catch in these fisheries. As discussed in section 2, these survey responses reemphasize the importance of knowing a change in the markets as the market information is placed as the second type of information mostly shared. Information on boat and gear is also important (37%) in these fisheries as reflected by the rule of many FCAs that more than one skipper¹⁸ are required to fish in one boat. These fishermen regard other fishermen as being close friends (49%) and having common in boat and gear (33%).

Frequency of sharing the six types of information listed above during a 2012 season was asked for each relationship in a scale of one to seven: 1 as frequent as everyday, 2 as every few days, 3 as once per week, 4 as once every two weeks, 5 as once per month, 6 as every two months, 7 as once during the season. An average skipper shared the important information with other skippers at least once a week during the season. To avoid confusion, the reverse coded index will be used for main estimation for frequency.

Trust indices

¹⁸ A term ‘skipper’ used in this study means a fisher who is independent and not hired for a fixed remuneration by a captain. Therefore a skipper may jointly own a boat or pay a fixed charter fees to an owner.

Trusting attitudes of skippers were measured based on the literature (Glaeser, Laibson, Scheinkman, & Soutter, 2000). The two questions from General Social Survey (GSS)¹⁹ were adopted and asked how strongly a person agrees or disagrees with the following statements: 1. These days you can't count on strangers, and 2. In dealing with strangers one is better off to be cautious until they have provided evidence that they are trustworthy. Subjects responded on a five-point Likert scale from 1: strongly disagree to 5: strongly agree. Summary statistics of the two trusting measures are presented in Table 2.8. To avoid confusion, the reverse coded index will be used for main estimation.

Measuring trust using Trust game²⁰ is unsuitable in this study because the only reliable parameter to be obtained by the trust game is trustworthiness, which was found to be correlated with the GSS survey responses as shown by Glaeser et al. (2000). Glaeser et al. (2000) compared different methods of measuring trust and found that the responses to the questions from the GSS were correlated with trustworthiness measured by the Trust game. This result suggests that general attitudinal questions can measure some aspect of trust although what the questions actually capture is different from what they were intended to capture. Adding two questions in the survey instead of conducting even a one-shot Trust game greatly saves time needed for completion of all the experiments including the surveys, which makes it easier for more fishermen to

¹⁹ General Social Survey is an established survey, a longest-running project by NORC at University of Chicago, that has been asking an American population about demographic, behavioural, and attitudinal questions since 1972. International Social Survey Program, established by the NORC, has been conducting the same survey internationally and a Japanese version also exists.

²⁰ In the trust game introduced by Berg et al. (1995) Investor has endowment of S and makes a transfer y between 0 and S to Trustee. Trustee receives $3y$ and can send back any amount x between 0 and $3y$ to Investor. Investor earns $S - y + x$. Trustee earns $3y - x$. An amount sent back by Trustee, x , measures positive reciprocity (Camerer & Fehr, 2004), which is referred as trustworthiness in Glaeser et al. (2000).

cooperate for the experiment. Furthermore, trusting behaviours measured by the Trust game were shown to be a poor indicator of trust and more correlated with risk attitudes (Karlan, 2005).

Empirical estimation

A careful sampling of groups based on observed characteristics has already helped us to construct a sample of revenue sharing fishery groups and the groups with similar traits but without revenue sharing.

Relative importance of the incomes from the Japanese surf clam fisheries may affect a decision to pool revenue and the outcomes and therefore may cause endogeneity. When the surf clams are not a primary source of income, a fisher may disregard the situation of the fishery or how to manage and fish the resources. We approximate importance of the surf clam fishery as shellfish shares in each FCA (total shellfish value/FCA value). The greater the shellfish share of a FCA is, the more likely not only the group member fishers but also the FCA managers may be to take the management seriously. The surf clam fishery in revenue sharing FCAs accounts for on average 2.8 percent of all species, ranging from 0.6 to 6.2 percent while in non-revenue sharing FCAs the surf clams value on average 1.9 percent with the minimum share of 0.9 and the maximum of 3.1 (Table 1.1). A nonparametric test with the alternative hypothesis ($\theta_{non-rev} > \theta_{rev}$) shows that these two groups are not significantly different at p value = 0.65 in terms of the shellfish share (Mann-Whitney-Wilcoxon test, distribution adjusted for small sample inference).

The absolute value of the FCAs, which each fishery group belongs to, may be important. The greater the FCA, the more resources may be available to the groups. The FCAs to which revenue sharing groups belong value on average 2,636 million yen as of 2012, compared with 2,884 million yen of non-revenue sharing FCAs (Table 1.1), although the difference is not statistically significant (p value = 0.65, Mann-Whitney-Wilcoxon test with $H_a: \theta_{non-rev} > \theta_{rev}$, adjusted for small sample inference).

Many surf clam skippers engage in other fisheries when the surf clam fishery is closed and the income from the surf clams is not the largest contributor for many skippers. Konbu seaweed or kelp is a big fishing industry in eastern Hokkaido, where most sampled fishery groups are located and most of the surf clam skippers, six (three in revenue sharing) of the ten fishery groups, engage in kelp fisheries (Table 1.1). The other fisheries the other groups engage in are salmon, shishamo, and gillnets targeting groundfish. No revenue sharing shellfish skipper has revenue sharing arrangement in the other fisheries.

Length of the surf clam fishing seasons can influence a decision to share revenue and the outcomes. In fact, an average revenue sharing group fished for a significantly shorter season from 1990 to 2012 (p value < 0.001, Mann-Whitney-Wilcoxon test). While longer fishing seasons can make it difficult for fishermen to coordinate and fish together as a group, they may have more flexibility to time the landings of the surf clams, which can affect the prices. On the other hand, revenue sharing arrangement may make it harder for the group to extend the fishing season, which can be more attributable to the size of the group.

In addition to the factors controlled at the time of sampling such as location, targeting species, and fishing technology, these observations lead us to believe that there is no significant or systematic difference in assignment of the treated groups (revenue sharing) based on observed characteristics that can affect the outcome and a decision to employ revenue sharing except for the season length.

OLS estimators are not appropriate as identification strategy; first, heterogeneity discussed above and endogeneity between the variables of interests and the outcomes can bias the OLS estimates; second, the small sample problem of ten groups can understate the standard deviation of the estimators. To address a part of the problems random-effects model with clustered standard errors is used for estimation.

$$y_{it} = \mathbf{X}_{it}'\boldsymbol{\beta} + \mathbf{Z}_{it}'\boldsymbol{\gamma} + \alpha + u_i + \epsilon_{it},$$

where i indexes groups and t years. Each group i contains T_i observations, which sum to N . y_{it} is an outcome of interest, either the prices per kilogram or the resource stock density in grams. \mathbf{X} contains the variables of interest, a rarely changing revenue sharing indicator and time-invariant social capital parameters. The two variables of interest can be put together in the same model if the assumption that there is no causal relationship between the two is appropriate. Nonetheless the two will be put together in one model to examine the indirect effects of the two as similarly used in Maccini and Yang (2009). \mathbf{Z} contains control variables that are different for each outcome. u_i is the random, time-invariant heterogeneity specific to the i th group and α is the mean of u_i . The panel structure of the sample is important because focus is on the average change in the outcome not on the absolute value of the outcome in some year. When the outcome variable is one of the subjective measures from the survey responses, the

data become cross-sectional with no subscript t . For this estimation we use the OLS estimator with clustered standard errors, as there is no benefit of using the GLS.

Control variables in the model for the prices include log of the number of months during a fishing season, the landings in kilograms in the other surf clam fisheries in Hokkaido, log of time trend, and a binary variable if the fishery has not switched to jet dredges.²¹ Control variables in the model for the resource stock are log of time trend and a binary variable for the FCAs I and J for the years before the area of the fishery changed due to port construction.²² Control variables with the subjective measures as a dependent variable include log of the number of years in shellfish fishing and log of the number of months of the fishing season in 2012.

One drawback of relying on the random-effects model instead of the fixed-effects model is that the model imposes a stronger assumption on the data at hand.²³ The GLS estimator is most appropriate when the unobserved heterogeneity is distributed normally ($u_i \sim N(\alpha, \sigma_u^2)$) and is uncorrelated with other explanatory variables ($E[u_i|X] = 0$). While the fixed-effects model is not feasible to estimate the coefficients for the time-invariant variables of interest in this study, it can be justified to choose the random-effects model over the fixed-effects model conditioned that

²¹ Most fishery groups have been using jet dredges during the entire sampling period except for the FCA H, which started to use them in 1995.

²² The FCAs I and J share the same fishing grounds and act as one in a number of decisions especially in terms of how to use the fishing grounds (a decision to go fishing, season length and more) and how to sustain the resources (catch limit, stock assessment, a TAC and more).

²³ Plümper & Troeger (2007) introduced an interesting estimator called fixed effects vector decomposition, which enables estimating the coefficients of time-invariant variables the fixed-effects model fails to estimate and further brings efficiency in estimation of the coefficients. Later Greene (2011a; 2011b) provided formal analysis for this estimator along with Breusch et al. (2011) and for efficiency Chatelain & Ralf (2010). To improve the model what is needed in this study is to relax the strong assumption of the random-effects model. This new estimator only relaxes the assumption of correlation between time-varying variables and the unobserved heterogeneity but not between time-invariant variables and the heterogeneity, which is a concern in this study (Greene, 2011; Plümper & Troeger, 2007).

selection at the time of sampling and controls in a regression remove most if not all observed heterogeneity that can capture unobserved heterogeneity. However, this assumption is not testable, which can be scrutinized only qualitatively.

One could argue that the estimates suffer from endogeneity. While revenue sharing and social capital parameters (cooperation, trust, information network) can affect the prices and the stock, higher prices and stock abundance could influence the decision to adopt revenue sharing and its stability, and the levels of cooperation, trust, and information network. First, as regards to individual fisher's decision to select into a fishery group under revenue sharing Carpenter and Seki (2011) discussed that selection bias for revenue sharing as an individual decision is not a significant problem in Japanese fisheries because each fisher did not self-select into the system. While individual decisions to adopt revenue sharing may not possess selection bias observed in selecting into job training, adoption of revenue sharing arrangement is possibly nonrandom. Preferences, value, and experience of individual fishers have been likely to affect the group decision to adopt revenue sharing. Suenaga (2008) emphasized the importance of involving fishers in the decision making process in Sandfish fishery in Japan. All the fishers surveyed in the Japanese surf clam fishery who gave valid response (64% of the respondents) suggested some involvement in the process for a change in operational rules in the fishery.

Furthermore, there may exist a mechanism that can affect the outcomes while being correlated with decisions to implement revenue sharing as well as the levels of social capital. One possible scenario is a catastrophic event in the shellfish fishery such as depletion of the resource due to overfishing, disease, weather, or all combined.

First, we asked in the survey whether they have seen the shellfish resource depleted or drastically decreased. After dropping 13 individuals who have been in the fishery for less than 10 years, the percentage of the respondents who reported “yes” ranges from 50 to 100 with a mean of 71. Seventy-one percent of revenue sharing fishers answered “yes” to the question while 72 percent of non-revenue sharing fishers did, which is not a statistically significant difference (Mann-Whitney-Wilcoxon test, p value = 0.63, Table 2.1). We also examined a more objective measure of resource stock density over the last 20 years. The mean density of revenue sharing groups was 0.59 kilograms per squared meter of a fishery and the mean density of non-revenue sharing groups was 0.54. We found these distributions between the two groups not statistically significantly different (Mann-Whitney-Wilcoxon test, p value = 0.61). This can be also supported by the fact that all the fishery groups, regardless of management systems, have been self-imposing a TAC for the last 20 years at least. Examination of these observations suggests that a possible catastrophic event like depletion of the resource is less likely to be associated with implementation of revenue sharing arrangement. However, a moderate variation across the groups is found on how many members shares a sense of crisis on their resource conditions. Together with no randomness of occurrence of revenue sharing arrangement, this calls for controlling heterogeneity, observed or unobserved, in the fishery groups that are correlated with implementation of revenue sharing arrangement as well as the levels of social capital.

Causal inference of the estimates crucially depends on how well unobserved heterogeneity is controlled based on the above discussion. The sampled fishery groups have been controlled on some important observables at the time of sampling; some

relevant characteristics of the group operation will be controlled in a regression in addition to time-invariant unobserved characteristics by exploiting a panel structure. Unobservables consist of in part that is correlated with observables and in part that is uncorrelated. The estimates are unbiased to the degree of how closely related the observables are to the unobservables and thus how well these observables capture unobserved heterogeneity.

Attention should be paid to another possible causal relationship that revenue sharing arrangement may affect development of social capital and conversely social capital induces employment of such arrangement. Specifically, revenue sharing arrangement possibly encourages cooperation and information network due to collective fishing operation accompanied by revenue sharing. On the other hand, trust in a community can affect a decision to employ revenue sharing because of the way the parameters are constructed specifically. When revenue sharing and social capital are an outcome of each other or even partly, the coefficients of the two variables need to be estimated separately (Angrist & Pischke, 2008); X must be a vector of only one variable at a time. The estimated coefficient contains not only the effect of revenue sharing but also the effect of social capital (trust) through revenue sharing when X is a vector of the revenue sharing indicator. Similarly, the coefficient of social capital estimated independently of revenue sharing includes a direct effect of social capital plus an indirect effect of revenue sharing through interacting with greater social capital (cooperation and information network). In addition, the two variables of interest together in the same model tests specification of an indirect effect, that is the

mechanism, through which revenue sharing and social capital interact each other and enhance the synergy of each effect, as similarly used in Maccini and Yang (2009).

Concerns for standard errors still remain. The literature has been casting doubts on inference based on cluster-robust standard errors when they are applied to the data containing a few clusters and the invariant variables of interest within a cluster (Angrist & Lavy, 2009; Bertrand, Duflo, & Mullainathan, 2004; Donald & Lang, 2007). Asymptotic justification of cluster-robust standard errors relies on the assumption that the number of clusters goes to infinity. Clearly, the data with ten clusters (groups) do not meet this assumption.

Although several solutions have been proposed, the wild cluster bootstrap analyzed in Cameron et al. (2008) is the most appropriate in this study; the wild cluster bootstrap can overcome the problems with having a few clusters and invariant variables within a cluster. The wild cluster bootstrap is different from a standard bootstrap method with cluster option commonly implemented by statistical software such as Stata or SAS. The wild cluster bootstrap forms pseudo-samples based on the residuals and uses “asymptotically pivotal” statistic. While the standard bootstrap directly evaluates the distribution of the OLS estimates, the wild cluster bootstrap forms the Wald statistics for every pseudo-sample and evaluates the distribution of these Wald statistics, which is “asymptotically pivotal”. A statistic is said to be asymptotically pivotal if its asymptotic distribution does not depend on any unknown parameters. With a few clusters this feature is crucial.

Another method, bias-reduced linearization (BRL) originally proposed by Bell and McCaffrey (2002) and applied by Angrist and Lavy (2009), can also achieve

asymptotic refinement. However, it is not suitable with the data in this study as underlying heteroskedasticity is expected to be severe due to the nature of unbalanced panels. Monte Carlo simulations in Cameron et al. (2008) show that when there is heteroskedasticity, BRL no longer improves inference whereas the wild cluster bootstrap still does.

The wild cluster bootstrap also solves the issue with invariant or rarely changing variables within a cluster. Forming pseudo-samples the wild cluster bootstrap based on pairs of a dependent variable and explanatory variables has a good chance of replicating the same pseudo-samples if explanatory variables do not vary within a cluster. The wild cluster bootstrap can avoid this by sampling based on residuals.

We extend the wild cluster bootstrap method detailed by Cameron et al. (2008) to the GLS estimator²⁴ and will present bootstrapped p-value using the wild cluster bootstrap-t method to guide us for better inference. Cameron et al. (2008) recommend to use it with the null hypothesis imposed. Instead of using two-point distribution originally applied by Cameron et al. (2008), Webb (2014) proposes to use six-point distribution, which is recommended especially for the data with a very few clusters less than ten clusters. This can greatly increase the number of possible values of the estimated Wald statistics from pseudo-samples.

²⁴ Cameron et al. (2008) note that this sampling method is applicable to any regression models with additive error.

2.5 Results

Although the overall direct effect of revenue sharing arrangement on either the economic outcome or the biological outcome is not evident, the indirect effect of revenue sharing affecting the perceived economic outcome through information network seems to exist. This suggests that merely sharing revenue does not necessarily result in a better economic outcome. However, revenue sharing arrangement can augment denser information network, which then affects the economic outcome in fisheries management. In addition, the overall effect of social capital on the outcomes is mixed, and the results highlight important characteristics of a community that is important to success in fisheries management. Tables 2.9 to 2.12 show selected results for objective measures of the ex-vessel prices and the resource stock density. Tables 2.13 to 2.15 show selected results for subjective measures of the perceived outcomes. Complete results are attached in Appendix.

Outcomes: prices and resource stocks

The results from estimation of cooperation suggest that unconditional cooperation plays a more important role than conditional cooperation in the Japanese surf clam fisheries. The groups with fishers who are more unconditionally cooperative are likely to receive higher prices through greater contribution to the collective efforts. A marginal increase in unconditional cooperation among fishers is expected to result in 43 yen higher prices while 21 yen higher prices are expected in conditional cooperation (Column 6, Table 2.9). However, this results is not robust across different specifications.

In contrast to the effect on the economic outcome, unconditional cooperation seems to negatively affect the biological outcome. The groups with fishers who are more unconditionally cooperative are likely to result in a less stock density in the long run. The marginal effect is 336 grams per m², which is more than 50 percent of the average stock density of 562 grams and thus significant in volume. However, after correcting for the small sample inference this effect becomes no longer significant (p -value = 0.11).

Estimation of the effects of trusting attitudes suggest that trust is more important to the economic outcome than to the biological outcome. According to the Table 2.10 the groups with fishers who are more trusting result in higher prices. A marginal increase in trusting attitudes among fishers raises the surf clam prices by 40 yen. This effect remains significant even with the wild cluster bootstrap (p -value = 0.07).

Comparing Columns (1) and (2) in Table 2.10, we did not find existence of the indirect effect of fishers' trusting attitudes on the outcome through encouraging employment of revenue sharing arrangement. Value of the coefficient of trust is unchanged (or slightly increased) after adding revenue sharing in regression. This suggests that the direct effect of trust is the only effect and there is no indirect effect of trust affecting revenue sharing.

The effect of information network is estimated in four aspects: information size, network density, varieties of information shared, and frequency of sharing such information. Among the four, the network size is suggested to have some influence on the prices with some ambiguity and the network density is strongly suggested to have

a great impact on the resource stock (Table 2.11). A marginal increase in network size increases the average prices of the surf clams by 26 yen. With the small sample correction implemented, however, the estimated coefficient is no longer significant at a conventional level (p -value = 0.11).

Another important result from information network is that greater standard deviation of the network density decreases the resource stock. This suggests that cohesion of a group as having similar network density among the members improves the resource stock density by 136 grams per m² at the margin, which remains barely significant with the wild cluster bootstrap (p -value = 0.10). Although the absolute level of the network density becomes important when it is explaining the outcome together with its standard deviation, the effect of cohesiveness of the information network is greater than the overall level of information network. Again, the effect of the network density seems to be a sole effect and does not include the indirect effect of revenue sharing interacting with the network density. Whether sharing revenue or not a cohesive network density in a fishery is important in improving the biological outcome.

Among the significant effects identified, trusting attitudes affect the prices most, which is robust in any specifications (Table 2.12). Different specifications in estimation of the resource stock reveal some ambiguity on the standard deviation of the network density.

Perceived outcomes

The results suggest that a higher level of cooperation does not necessarily lead to better perceptions of economic or biological outcomes; neither unconditional nor conditional cooperation shows explanatory power for any outcomes (Table 2.13).

While trust seems to matter in the economic outcome, it doesn't influence the biological outcome (Table 2.14). Fishers with higher trusting attitudes are more likely to feel that their income has been increasing or at least remaining at a certain level. However, this estimated effect is no longer significant after being corrected for small sample inference (p -value = 0.11).

Among the four aspects of information network, the varieties of information shared and frequency of sharing such information seem to influence the management outcomes. First, more varieties of information shared among fishers lead to a better economic outcome, and this effect seems to be interacted with revenue sharing (Columns 3 and 4, Table 2.14). The magnitude of the effect of varieties of information shared decreases but with gain in significance for the effect of revenue sharing while the explanatory power of the model increases. This suggests that fishers are more likely to consider their profits as increasing or at least remaining at a certain level not only when they share more varieties of information—direct effect of information sharing—but also when they pool revenue and exchange more information—indirect effect of revenue sharing through information sharing. These effects remain significant even with small sample inference (all p value < 0.1). Frequency of sharing information also increases fishers' profits, but there seems to be no indirect effect of revenue sharing. Among all the effects at work the frequency of sharing information has the

most explanatory power although it loses statistical significance with small sample inference (upper Column 7 of Table 2.14).

Although revenue sharing, cooperation, or trust seems to have no effect on the perceived biological outcome, the only effect that is suspected to hold some influence is the varieties of information shared. When fishers share more types of information, they are more likely to feel that their resource stock conditions have been improving or at least maintaining at a certain level. However, more information is not necessarily related to more information on the stock and in fact this effect is no longer significant after implementing small sample inference (p value = 0.13).

Breaking down what types of information being shared, we identified information on specific hot-spots and high gear density areas is the types of information that affects the economic outcome (Table 2.15). These two are not severely correlated (correlation = 0.23). Revenue sharing arrangement encourages both types of information in such a way that it improves the perceived economic outcome. However, information on high gear density areas is suspected to have little more explanatory power than specific hot-spots. The same estimation with the biological outcome finds no significant effect on any types of information except in buyer information, which confirms no reasonable association of the varieties of information with the biological outcome.

2.6 Discussion

The results of the data analysis provide us insights into how management outcomes in a fishery can be improved. The first lesson is that implementing revenue sharing

arrangement does not necessarily generate synergies in harvesting efforts and other collective efforts for the stock enhancement. Theoretically revenue sharing arrangement can improve economic and biological outcomes in a fishery and in particular the Japanese surf clam fisheries in Hokkaido can do so by generating synergies because revenue sharing supports their group incentives. However, the data and the results of the analysis did not support this prediction overall; no direct effect of revenue sharing was found. Especially for the effect on the biological outcome it may be suggested that a self-imposed TAC that has been already in place in all fishery groups for many years suffices to ensure the health of the resource stocks. However, this result does not necessarily suggest that revenue sharing arrangement should never be employed; revenue sharing can achieve economic efficiency through other mechanisms such as cost reduction.

Second, indirect effect of revenue sharing and social capital variables was found in the varieties of information shared. Revenue sharing partly contributes to the effect of the varieties of information; the fishers who share revenue are found to exchange more varieties of information, which jointly contributes to the better perceived economic outcome. This is particularly so in exchanging information on specific hot-spots and high gear density areas. However, the effect of the varieties of information is not robust in all specifications; it loses significance when the two effects of the varieties of information and frequency of exchanging information are in the same model. The effect of sharing information more frequently dominates the effect of sharing more varieties of information, but the effect of frequency is not associated with employment of revenue sharing in such a way to affect the perceived

outcomes. Although it is smaller than the effect of sharing information more frequently, the effect of sharing more types of information can be enhanced by revenue sharing arrangement meaningfully. This can be important policy implication for the fisheries that suffer from inefficiency due to a lack of information sharing among fishers.

Third, among the various aspects of social capital examined in this study the following two lessons are noteworthy; fostering general trust in a community, not necessarily directed towards fellow fishers, is key in economic success and information sharing among fishers is critical in a fishery in both economic and biological terms. The comprehensive analysis using different measures of management outcomes demonstrates a consistent importance of information sharing while different measures of the outcomes highlight different aspects of information sharing (the network size matters for the prices, the network density for the resource stock, the varieties of information and frequency for the perceived outcomes).

The results of the analysis of the prices as well as the perceived economic success support importance of trust although the estimated effect with fishers' perceptions was not consistently robust. This implies that trust in a community in general can create good teamwork in a fishery group and enhance the effect of collective efforts, which eventually yields better prices and increases income.

While the network size and the density have a positive impact on the outcomes measured with the prices and the resource stock density, the varieties of information shared and the frequency of exchanging such information affect the outcomes measured as the perceptions of fishers. A positive effect of the information network

implies that information is key in economic success of a fishery however it is measured. As discussed earlier revenue sharing arrangement can strengthen some aspects of the information network meaningfully to improve the perceived economic outcomes. These results suggest that revenue sharing arrangement can be an effective policy tool to reinforce the information network in a fishery, which generates synergies in fishing operation and leads to better management outcomes.

Implementation of this arrangement may need to assure that free-riding is costly. In the case of the Japanese surf clam fisheries in Hokkaido all the revenue sharing groups have collective fishing operation, which makes it easy to monitor the efforts of other members.

As fishers exchange information from more diverse fishers, on average as a group they can fish better possibly because the information enables them to make a better decision on where to fish and how to utilize the stock enhancement in coordination with harvesting effort. The fact that the absolute size of network matters more than the density also implies that more sources of information are more beneficial regardless of how comprehensive a network is within a fishing group. This can be true because a network that an individual member has needs not to be comprehensive to spread information across the group. In fact, the most efficient network should be structured in such a way that an individual needs to have a minimal size of the network to spread information across the group. However, a caution needs to be exercised to infer the estimated effect of the network size due to a moderate linear correlation between the information size reported by the fishers and a possible size of information network in their corresponding groups (correlation = 0.64).

An interesting aspect of the effect of the network density on the stock is that when some fishers in a group exchange information with more fishers than other fishers in the same group do, it deteriorates the resource conditions. Thus, a group with more cohesion in terms of how dense the information network is across its members can achieve better resource conditions over time. More cohesion in terms of the network density can imply more efficient structures of information networks. This implies that with good organization of information network the fishery groups can spread relevant information evenly across the group, which enables the group to more successfully coordinate harvesting efforts or/and stock enhancement efforts as a group. This feature seems to be more important for the health of the stock than the prices.

On average fishers in this sample shared two types of information during the 2012 season, and a type of information shared most involved specific hot-spots of the clams (61% of the relationships²⁵), followed by market information. The result from Table 2.14 suggests that, for example, the fishers who share three types of information, boat and gear in addition to hot-spots and market, are more likely to experience better outcomes in both economic and biological terms than the fishers who share two types of information, hot-spots and market. Among the types of information shared, specific hot-spots and high gear density areas are the information that actually affected the economic outcome. These types of information that are related to location choice in fishing can affect fishing outcomes more considerably than buyer or market information in a sense that sharing buyer or market information does not strategically alter the way fishers fish.

²⁵ Multiple answers are allowed.

The information was discussed on average once per week, and the fishers who share such information more frequently are more likely to perceive a better economic outcome. Thus, similar to the network size exchanging more types of information and exchanging information more frequently can help fishers to fish more collectively and thus efficiently.

While cooperation whether unconditional or conditional does not influence the outcomes measured subjectively, estimation for the prices and the resource stocks shows some influence of unconditional cooperation although the estimates are not robust with small sample inference. It is especially puzzling that fishers with more cooperative nature leads to deterioration in the stock conditions. Although this may be the case through some unknown mechanism, the estimates may be suffering from endogeneity. If the stock conditions have not been favorable historically, fishers may have been working collectively over time, which could have resulted in more cooperation measured in 2013. If this is the case, the estimate from the model is biased and is not a true effect of cooperation on the resource stock. On the other hand, the trust indices are less likely to suffer from endogeneity because the survey questions relate to more general attitudes not necessarily directed towards other fishers.

The results from cooperation parameters also suggest that conditional cooperation does not play any role in the outcomes of a fishery while some role of unconditional cooperation is suspected. This may imply that the VCM did not elicit a great difference in fishers' responses to what others did in the game. Although fishers did respond at a statistically significant level, the magnitude of response was insignificant in an economic sense, and the model was not able to capture a significant

individual variation in the response (Table 2.5). Thus, construction of conditional cooperation relied on the variation estimated insignificantly while construction of unconditional cooperation was based on the variation estimated significantly.

One final note to our results is that the results from ten fishery groups may suffer from a small sample problem. Unless the outcomes are consistently, significantly different in the two groups the model may not be able to capture a subtle difference between the two if any with five groups in each. We provided asymptotic refinement with the wild cluster bootstrap to increase confidence in our estimates, but this does not necessarily minimize the variance. This leaves some room for future study to refine the estimates with even a greater, better sample.

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Table 2.1. Summary Statistics of Sampled Fishery Groups

FCA	(1) Shellfish fishing started	(2) Revenue sharing started	(3) Shellfish group size	(4) Surf clam value (million yen)	(5) FCA value (million yen)	(6) Shellfish share (4) /(5)	(7) Other fishery *	(8) # of partici pants	(9) Median age	(10) Have seen resource depleted (%) **
A	Pre- 1950	1983-8	32	84.1	1,729	4%	Gillnet	7	53	57
B	Pre- 1956	1967	90	71.8	3,000	6%	Kelp	17	52	78
C	Pre- 1962	2002	24	26.6	5,016	2%	Kelp	8	53	71
D	1976	1990	6	18.0	2,267	1%	Kelp	6	49.5	60
E	1964	1994	47	93.0	1,166	2%	Salmon	8	51.5	88
Treatment Groups Mean			40	59	2,636	3%	Kelp	9	52	71
F	Pre-1960		75	95.2	3,080	3%	Gillnet	9	56	50
G	Pre-1949		10	27.2	4,136	2%	Kelp	9	59	75
H	1940		73	69.7	4,572	2%	Kelp	11	57	64
I	1931		6	41.6	1,327	1%	Shisha mo	1	60	100***
J	1954-70		5	26.4	1,305	2%	Kelp	3	36	
Control Groups Mean			34	52	2,884	2%	Kelp	7	54	72

Note: As of 2012.

* The column (7) lists major fishery, in which many, if not all, shellfish fishermen in each group engage when the surf clam fisheries are closed. The letters are bold if monetary value of the other fishery is greater than the surf clams. ** The column (10) lists the percentage of the respondents who reported to have seen the resource depleted or drastically decreased after dropping the individuals who haven been in the fishery for less than ten years. *** The FCAs I and J collectively manage the same resource stock.

Table 2.2 Summary statistics of perceptions towards the fishery

	<i>N</i>	Mean	Std. Dev.	Min	Max
Perceptions towards resource conditions	77	3.40	0.86	2	5
Perceptions towards economic performance	77	3.30	0.86	1	5

Note: Not all subjects completed all the questions in the survey.

Table 2.3 Summary statistics of the outcome variables

	<i>N</i>	Mean	Std. Dev.	Min	Max
Ex-vessel prices (yen per kg)	225	464.05	168.86	153.30	858.30
Stock density (grams per m ²)	193	562.35	374.38	51.09	1,633.40

Note: Ex-vessel prices are real prices (base year 2010).

Table 2.4 Summary Statistics of Participants

	<i>N</i>	Mean	Std. Dev.	Min	Max
Age	78	53.24	10.21	26	79
Education (1: Junior high school - 6: Graduate degree)	78	1.73	0.60	1	4
Household size (persons)	77	2.77	1.72	0	6
Shellfish fishing experience (years)	73	23.93	13.87	1	55

Note: Not all participants who participated in the experiment completed all the questions in the survey.

Table 2.5 Estimating Cooperation Parameters

Dependent variable: Amount contributed by i in session j at round t	
β_0 : Constant	1,272.57*** (0.00)
β_1 : Total group contribution excluding oneself in the previous round	0.08** (0.01)
Variance of u_j^1 (Random intercept for sessions)	45,915.791 (0.58)
Variance of u_{ij}^2 (Random intercept for individuals)	996,737.9** (0.05)
Variance of u_{ij}^3 (Random slope for individual β_1)	0.007 (0.63)
Observations	666
Log-likelihood	-4,222.41

Notes: P-value in parentheses. Multilevel Tobit Regression.

Table 2.6 Summary Statistics of Cooperation Parameters

	N	Mean	Std. Dev.	Min	Max
Conditional cooperation	78	0.00	0.02	-0.05	0.08
Unconditional cooperation	78	0	844	-1,500	2,495

Note: Eighty subjects participated, two of whom were dropped from the analysis.

Table 2.7 Summary Statistics of Information Network Indices

	N	Mean	Std. Dev.	Min	Max
Network size (persons)	78	10.58	15.03	0	90
Network density (%)	78	31.08	34.50	0	100
Varieties of info (1-6 types)	60	2.05	1.27	1	5
Frequency (1: Everyday - 7: Once in season)	63	2.71	1.93	1	7

Notes: Not all subjects completed all the questions in the survey. The last two rows have a particularly lower response rate because these questions are part of the section that requires personal information.

Table 2.8 Summary Statistics of Trust Indices

	<i>N</i>	Mean	Std. Dev.	Min	Max
Trust 1 (<i>These days you can't count on strangers</i>)	78	3.06	0.67	1	4
Trust 2 (<i>In dealing with strangers one is better off to be cautious until they have provided evidence that they are trustworthy</i>)	77	3.71	0.87	1	5

Notes: Subjects responded on a five-point scale from 1: strongly disagree to 5: strongly agree. Not all subjects completed all the questions in the survey.

Table 2.9 Estimated Effect of Cooperation on Price/Stock

Dependent Variable: <i>Real price</i> (yen per kg)						
	(1)	(2)	(3)	(4)	(5)	(6)
Revenue sharing	2.8 (0.88)		2.2 (0.91)		17.3 (0.20)	
Conditional (mean)		9.3 (0.24)	9.4 (0.23)			20.8*** (0.00) [0.05]
Unconditional (mean)				35.7*** (0.00) [0.15]	36.5*** (0.00) [0.14]	42.6*** (0.00) [0.08]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	225	225	225	225	225	225
Number of groups	10	10	10	10	10	10
Wald chi2	14333	14529	27665	2597	3035	13325
Dependent Variable: <i>Stock density</i> (grams per m2)						
	(1)	(2)	(3)	(4)	(5)	(6)
Revenue sharing	38.6 (0.67)		38.8 (0.68)		31.9 (0.72)	
Conditional (mean)		133.6 (0.24)	138.5 (0.25)			74.3 (0.38)
Unconditional (mean)				-335.6*** (0.00) [0.11]	-336.0*** (0.00) [0.15]	-316.2*** (0.00) [0.18]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	192	192	192	192	192	192
Number of groups	9	9	9	9	9	9
Wald chi2	509425	82098	137844	695139	683981	770148

*** p<0.01, ** p<0.05, * p<0.1

Notes: GLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. All cooperation parameters are standardized. For the estimation of the stock the FCAs I and J in the table 2.1 share their stock variable because they manage and harvest in the same fishing grounds.

Table 2.10 Estimated Effect of Trust on Price/Stock

Dependent Variable: <i>Real price</i> (yen per kg)					
	(1)	(2)	(3)	(4)	(5)
Revenue sharing		14.5 (0.27)		21.6 (0.14)	
Trust (mean)	40.1*** (0.00) [0.07]	40.8*** (0.00) [0.07]			26.8** (0.05) [0.64]
Trust (stdev)			35.3*** (0.00) [0.25]	38.3*** (0.00) [0.18]	15.0 (0.12)
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	225	225	205	205	205
Number of groups	10	10	9	9	9
Wald chi2	6201	6411	18714	4930	1997

Dependent Variable: <i>Stock density</i> (grams per m2)				
	(1)	(2)	(3)	(4)
Revenue sharing		39.5 (0.66)		38.1 (0.67)
Trust (mean)	-153.6 (0.13)	-152.9 (0.16)		
Trust (stdev)			-109.2 (0.11)	-104.7 (0.14)
Control variables	Yes	Yes	Yes	Yes
Observations	192	192	192	192
Number of groups	9	9	9	9
Wald chi2	3.708e+0 6	1.020e+0 7	3.525e+0 6	6.820e+0 6

*** p<0.01, ** p<0.05, * p<0.1

Notes: GLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. All trust parameters are Trust 2 from the table 2.8 and are standardized. The standard deviation from one FCA is missing in the upper part because only one skipper participated from that FCA in the joint experiment with another FCA. For the estimation of the stock the FCAs I and J in the table 2.1 share their stock variable because they manage and harvest in the same fishing grounds.

Table 2.11 Estimated Effect of Information Network on Price/Stock

Dependent Variable: <i>Real price</i> (yen per kg)					
	(1)	(2)	(3)	(4)	(5)
Revenue sharing		-5.8 (0.77)		-3.5 (0.82)	
Network size (mean)	25.8** (0.04) [0.11]	27.0* (0.10) [0.24]			22.5 (0.24)
Network size (stdev)			20.0 (0.24)	21.0 (0.23)	2.8 (0.90)
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	225	225	205	205	205
Number of groups	10	10	9	9	9
Wald chi2	15856	39896	24413	3901	49744
Dependent Variable: <i>Stock density</i> (grams per m2)					
	(1)	(2)	(3)	(4)	(5)
Revenue sharing		38.9 (0.67)		43.2 (0.64)	
Network density (mean)	15.9 (0.88)	12.5 (0.91)			259.1*** (0.00) [0.06]
Network density (stdev)			-135.6** (0.04) [0.10]	-142.1** (0.04) [0.09]	-309.5*** (0.00) [0.03]
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	192	192	192	192	192
Number of groups	9	9	9	9	9
Wald chi2	938026	1.287e+06	510392	528358	1.871e+06

*** p<0.01, ** p<0.05, * p<0.1

Notes: GLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. All information network parameters are standardized. The standard deviation from one FCA is missing in the upper part because only one skipper participated from that FCA in the joint experiment with another FCA. For the estimation of the stock the FCAs I and J in the table 2.1 share their stock variable because they manage and harvest in the same fishing grounds.

Table 2.12 Estimated Effect of Social Capital on Price/Stock

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Real price</i> (yen per kg)			<i>Stock density</i> (grams per m2)		
Unconditional (mean)	11.9 (0.37)	33.8*** (0.00) [0.02]		-390.5*** (0.00) [0.15]	-320.6*** (0.00) [0.13]	
Trust (mean)	31.8** (0.02) [0.04]		38.7*** (0.00) [0.10]	215.6*** (0.01) [0.20]		-158.9** (0.03) [0.39]
Network size (mean)		23.8*** (0.00) [0.03]	1.9 (0.87)			
Network density (stdev)					-111.8*** (0.00) [0.10]	-139.6* (0.06) [0.17]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	225	225	225	192	192	192
Number of panel	10	10	10	9	9	9
Wald chi2	8243	1909	7959	7.061e+0 6	6.666e+0 6	3.241e+0 6

*** p<0.01, ** p<0.05, * p<0.1

Notes: GLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. All social capital parameters are standardized. All trust parameters are Trust 2 from the table 2.8 except in column (4) with Trust 1. For the estimation of the stock the FCAs I and J in the table 2.1 share their stock variable because they manage and harvest in the same fishing grounds.

Table 2.13 Estimated Effect of Rev. Sharing/Cooperation on Perceived Outcomes

Dependent Variable: Perceptions towards <i>economic</i> outcome					
	(1)	(2)	(3)	(4)	(5)
Revenue Sharing	0.18 (0.39)		0.32 (0.11)		0.28 (0.15)
Unconditional		0.24 (0.12)	0.24 (0.12)		
Conditional				-0.15 (0.15)	-0.14 (0.19)
Control	Yes	Yes	Yes	Yes	Yes
Observations	77	71	71	71	71
F	0.979	2.715	4.132	2.219	3.591
Root MSE	0.857	0.846	0.838	0.862	0.858
Dependent Variable: Perceptions towards <i>biological</i> outcome					
	(1)	(2)	(3)	(4)	(5)
Revenue Sharing	-0.02 (0.94)		-0.00 (1.00)		-0.02 (0.93)
Unconditional		0.05 (0.60)	0.05 (0.61)		
Conditional				-0.13 (0.33)	-0.13 (0.32)
Control	Yes	Yes	Yes	Yes	Yes
Observations	77	71	71	71	71
F	0.730	0.608	0.789	2.122	7.168
Root MSE	0.868	0.892	0.899	0.884	0.891

*** p<0.01, ** p<0.05, * p<0.1

Notes: OLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. All cooperation parameters are standardized. Control variables, all in logarithm, are the number of years in shellfish fishing and the number of months in 2012 season except in model 1 with the number of months only.

Table 2.14 Estimated Effect of Trust/Information Network on Perceived Outcomes

Dependent Variable: Perceptions towards <i>economic</i> outcome							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rev. Sharing		0.24 (0.24)		0.45** (0.04) [0.04]		0.23 (0.26)	0.18 (0.44)
Trust	0.17* (0.09) [0.11]	0.17 (0.11) [0.14]					0.09 (0.34)
Varieties of info shared			0.26** (0.03) [0.04]	0.22* (0.05) [0.06]			0.12 (0.23)
Frequency					0.38** (0.01) [0.01]	0.33** (0.03) [0.03]	0.26* (0.08) [0.14]
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	70	70	54	54	58	58	53
F	3.700	5.392	3.175	4.886	5.380	5.205	5.482
Root MSE	0.842	0.840	0.872	0.851	0.810	0.811	0.824
Dependent Variable: Perceptions towards <i>biological</i> outcome							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rev. Sharing		-0.05 (0.84)		0.10 (0.73)		-0.08 (0.77)	0.00 (0.99)
Trust	-0.07 (0.65)	-0.07 (0.65)					
Varieties of info shared			0.32* (0.07) [0.13]	0.31* (0.08) [0.16]			0.28* (0.10) [0.18]
Frequency					0.19 (0.13)	0.21** (0.05) [0.07]	0.11 (0.25)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	70	70	54	54	58	58	54
F	0.468	0.476	6.779	4.362	1.485	3.776	3.461
Root MSE	0.877	0.884	0.881	0.889	0.915	0.922	0.893

*** p<0.01, ** p<0.05, * p<0.1

Notes: OLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. The trust parameters are Trust 1 from the table 2.8. All social capital parameters are standardized. Control variables, all in logarithm, are the number of years in shellfish fishing and the number of months in 2012 season.

Table 2.15 Estimated Effect of Varieties of Information on Perceived Outcomes

Dependent Variable: Perceptions towards <i>economic</i> outcome						
	(1)	(2)	(3)	(4)	(5)	(6)
Revenue sharing		0.59** (0.03) [0.04]		0.62** (0.02) [0.02]		0.63** (0.01) [0.02]
Specific hot-spots	0.19* (0.09) [0.09]	0.21* (0.07) [0.09]			0.17 (0.12)	0.18* (0.09) [0.11]
High gear density areas			0.18** (0.03) [0.10]	0.21** (0.01) [0.09]	0.17** (0.05) [0.12]	0.20** (0.03) [0.11]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	54	54	54	54	54	54
F	2.227	3.181	4.044	9.621	3.760	9.614
Root MSE	0.894	0.853	0.891	0.845	0.888	0.838

*** p<0.01, ** p<0.05, * p<0.1

Notes: OLS estimates. Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. Control variables are the number of existing relationships, log of the number of years in shellfish fishing, and log of the number of months in 2012 season.

Figure 2.1 Hypotheses

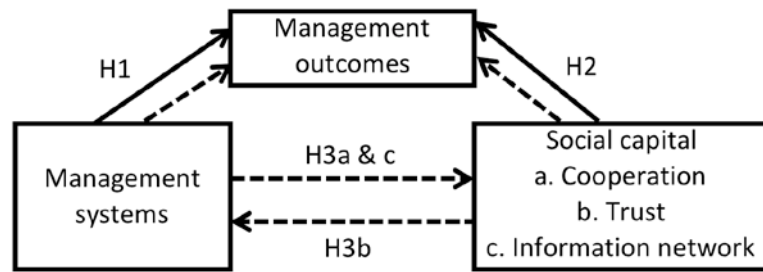


Figure 2.2 Setup of the Experiment



Appendix 2.1 Wild Cluster Bootstrap

Steps to conduct the wild cluster bootstrap with the null hypothesis imposed and six-point distribution are detailed in this appendix. These steps follow Cameron et al. (2008). Cameron and Miller (2015) is a reference for implementation.

Consider a model $y_{ig} = x'_{ig}\beta + u_{ig}$ with G clusters and each cluster consists of $n_g, i = 1, \dots, n_g, g = 1, \dots, G$ observations with $E[u_g] = 0, E[u_g u'_g] = \Sigma_g$, and $E[u_g u'_h] = 0$ for cluster $h \neq g$. Then the cluster-robust variance estimator is

$$\hat{V}[\hat{\beta}] = [\sum_{g=1}^G X'_g X_g]^{-1} \left[\frac{G}{G-1} \sum_{g=1}^G (X'_g \hat{u}_g)(\hat{u}'_g X_g) \right] [\sum_{g=1}^G X'_g X_g]^{-1}.$$

1. Determine the null hypothesis $H_0: \beta_k - \beta_k^0$. From the original sample, form Wald statistics, $w = (\hat{\beta}_k - \beta_k^0)/s_{\hat{\beta}_k}$ using $\hat{V}[\hat{\beta}]$.

Also, obtain the restricted OLS estimator $\hat{\beta}^R$ that imposes the null hypothesis, and the associated restricted OLS residuals $\{\hat{u}_1^R, \dots, \hat{u}_G^R\}$.

2. Do B iterations. On the b^{th} iteration,

- a. Form a sample of G clusters $\{(y_1^*, X_1^*), \dots, (y_G^*, X_G^*)\}$. For each cluster $g = 1, \dots, G$, form

$$\hat{u}_g^{R*} = -\sqrt{\frac{3}{2}} \hat{u}_g^R \text{ with } p = \frac{1}{6},$$

$$\hat{u}_g^{R*} = -\sqrt{\frac{2}{2}} \hat{u}_g^R \text{ with } p = \frac{1}{6},$$

$$\hat{u}_g^{R*} = -\sqrt{\frac{1}{2}} \hat{u}_g^R \text{ with } p = \frac{1}{6},$$

$$\hat{u}_g^{R*} = \sqrt{\frac{1}{2}} \hat{u}_g^R \text{ with } p = \frac{1}{6},$$

$$\hat{u}_g^{R*} = \sqrt{\frac{2}{2}} \hat{u}_g^R \text{ with } p = \frac{1}{6},$$

$$\hat{u}_g^{R*} = -\sqrt{\frac{3}{2}} \hat{u}_g^R \text{ with } p = \frac{1}{6},$$

and then form $\hat{y}_g^* = X_g' \hat{\beta}^R + \hat{u}_g^{R*}, g = 1, \dots, G$.

- b. Calculate the Wald statistics, $w_b^* = (\hat{\beta}_{k,b}^* - \beta_k^0) / s_{\hat{\beta}_{k,b}^*}$, where $\hat{\beta}_{k,b}^*$ and $s_{\hat{\beta}_{k,b}^*}$ are obtained from unrestricted OLS estimation using the b^{th} pseudo-sample, with $s_{\hat{\beta}_{k,b}^*}$ computed as in step 1.

3. Reject H_0 at level α iff $w < w_{[\alpha/2]}^*$ or $w < w_{[1-(\alpha/2)]}^*$, where $w_{[q]}^*$ denote the q^{th} quantile of w_1^*, \dots, w_B^* .

For GLS estimation, replace all the OLS estimators with the GLS estimator.

Appendix 2.2 Complete Results

Table 2.16 Estimated Effects of Cooperation on Price (Complete)

Dependent Variable: Real price (yen per kg)											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Revenue sharing	2.8 (0.88)		2.2 (0.91)		-6.2 (0.78)		17.3 (0.20)		0.7 (0.97)		14.8 (0.24)
Conditional (mean)		9.3 (0.24)	9.4 (0.23)							20.8*** (0.00)	21.1*** (0.00)
Conditional (stdev)				6.1 (0.77)	6.0 (0.77)						
Unconditional (mean)						35.7*** (0.00)	36.5*** (0.00)			42.6*** (0.00)	43.0*** (0.00)
Unconditional (stdev)								25.1* (0.06)	29.3** (0.03)		
Catch in other FCAs	-0.0*** (0.00)	-0.0*** (0.01)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.01)	-0.0*** (0.01)	-0.0*** (0.01)	-0.0*** (0.00)	-0.0*** (0.01)
ln(season months)	-50.1** (0.03)	-51.2** (0.03)	-50.7** (0.04)	-56.0** (0.02)	-56.1** (0.03)	-37.3** (0.04)	-29.7* (0.07)	-32.7* (0.07)	-15.7 (0.35)	-43.2** (0.04)	-39.1** (0.04)
Binary (1 if non jet dredges)	-118.3*** (0.00)	-119.0*** (0.00)	-118.7*** (0.00)	-112.9*** (0.00)	-111.3*** (0.00)	-131.0*** (0.00)	-128.6*** (0.00)	-128.2*** (0.00)	-143.1*** (0.00)	-136.2*** (0.00)	-135.8*** (0.00)
ln(time trend)	-212.1*** (0.00)	-211.8*** (0.00)	-212.1*** (0.00)	-206.3*** (0.00)	-205.7*** (0.00)	-212.5*** (0.00)	-214.1*** (0.00)	-206.1*** (0.00)	-205.1*** (0.00)	-213.1*** (0.00)	-214.6*** (0.00)
Constant	1,217.5*** (0.00)	1,218.7*** (0.00)	1,216.5*** (0.00)	1,230.3*** (0.00)	1,228.7*** (0.00)	1,209.4*** (0.00)	1,197.1*** (0.00)	1,220.8*** (0.00)	1,233.0*** (0.00)	1,201.1*** (0.00)	1,192.0*** (0.00)
Observations	225	225	225	205	205	225	225	205	205	225	225
Number of groups	10	10	10	9	9	10	10	9	9	10	10
Wald chi2	14333	14529	27665	50015	95408	2597	3035	1324	1256	13325	20353

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.17 Estimated Effects of Cooperation on Stock (Complete)

Dependent Variable: Stock density (grams per m2)											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Revenue sharing	38.6 (0.67)		38.8 (0.68)		39.7 (0.66)		31.9 (0.72)		43.3 (0.64)		37.7 (0.68)
Conditional (mean)		133.6 (0.24)	138.5 (0.25)							74.3 (0.38)	78.9 (0.39)
Conditional (stdev)				-79.3 (0.45)	-78.2 (0.45)						
Unconditional (mean)						-335.6*** (0.00)	-336.0*** (0.00)			-316.2*** (0.00)	-315.1*** (0.00)
Unconditional (stdev)								-239.5* (0.08)	-245.3* (0.09)		
ln(season months)	-93.4 (0.38)	-97.1 (0.34)	-97.2 (0.37)	-92.3 (0.35)	-94.0 (0.38)	-98.9 (0.31)	-99.0 (0.33)	-103.2 (0.31)	-102.4 (0.35)	-104.0 (0.29)	-102.3 (0.34)
Binary (1 if before area change)	-741.7*** (0.00)	-725.1*** (0.00)	-732.1*** (0.00)	-738.6*** (0.00)	-744.4*** (0.00)	-745.2*** (0.00)	-749.1*** (0.00)	-735.8*** (0.00)	-742.8*** (0.00)	-742.5*** (0.00)	-747.0*** (0.00)
ln(time trend)	110.2** (0.02)	116.3*** (0.00)	110.6** (0.02)	115.8*** (0.00)	109.9** (0.02)	115.3*** (0.00)	110.6** (0.02)	116.1*** (0.00)	109.7** (0.02)	115.4*** (0.00)	109.9** (0.02)
Constant	418.4 (0.12)	406.1* (0.10)	401.6 (0.10)	433.6 (0.10)	431.2 (0.11)	495.6* (0.05)	492.4* (0.05)	484.0* (0.07)	479.7* (0.08)	487.1** (0.05)	479.6* (0.05)
Observations	192	192	192	192	192	192	192	192	192	192	192
Number of groups	9	9	9	9	9	9	9	9	9	9	9
Wald chi2	509425	82098	137844	1.382e+06	2.146e+06	695139	683981	312890	529732	770148	2.130e+06

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.18 Estimated Effects of Trust on Price (Complete)

Dependent Variable: Real price (yen per kg)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Revenue sharing		0.4 (0.99)		-6.4 (0.76)		14.5 (0.27)		21.6 (0.14)	
Trust 1 (mean)	5.9 (0.46)	5.8 (0.52)							
Trust 1 (stdev)			9.6 (0.65)	9.4 (0.67)					
Trust 2 (mean)					40.1*** (0.00)	40.8*** (0.00)			26.8** (0.05)
Trust 2 (stdev)							35.3*** (0.00)	38.3*** (0.00)	15.0 (0.12)
Catch in other FCAs	-0.0*** (0.01)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.01)	-0.0** (0.03)	-0.0*** (0.01)	-0.0** (0.01)	-0.0** (0.01)
ln(season months)	-49.3** (0.04)	-49.2** (0.05)	-55.3** (0.02)	-55.5** (0.03)	-41.8** (0.04)	-31.2* (0.08)	-57.7** (0.01)	-54.5*** (0.00)	-48.0*** (0.00)
Binary (1 if non jet dredges)	-118.3*** (0.00)	-118.0*** (0.00)	-112.8*** (0.00)	-111.1*** (0.00)	-119.8*** (0.00)	-118.6*** (0.00)	-111.8*** (0.00)	-110.0*** (0.00)	-115.9*** (0.00)
ln(time trend)	-211.8*** (0.00)	-211.9*** (0.00)	-206.4*** (0.00)	-205.8*** (0.00)	-212.6*** (0.00)	-214.4*** (0.00)	-206.4*** (0.00)	-208.6*** (0.00)	-207.3*** (0.00)
Constant	1,215.7*** (0.00)	1,214.1*** (0.00)	1,228.4*** (0.00)	1,227.3*** (0.00)	1,188.7*** (0.00)	1,163.2*** (0.00)	1,226.2*** (0.00)	1,218.2*** (0.00)	1,201.7*** (0.00)
Observations	225	225	205	205	225	225	205	205	205
Number of groups	10	10	9	9	10	10	9	9	9
Wald chi2	18209	40414	25673	62464	6201	6411	18714	4930	1997

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.19 Estimated Effects of Trust on Stock (Complete)

Dependent Variable: Stock density (grams per m2)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Revenue sharing		38.8 (0.66)		40.6 (0.66)		39.5 (0.66)		38.1 (0.67)	
Trust 1 (mean)	65.1 (0.74)	56.9 (0.77)							
Trust 1 (stdev)			79.1 (0.50)	84.5 (0.49)					
Trust 2 (mean)					-153.6 (0.13)	-152.9 (0.16)			-157.6 (0.45)
Trust 2 (stdev)							-109.2 (0.11)	-104.7 (0.14)	4.2 (0.97)
ln(season months)	-91.7 (0.35)	-93.6 (0.38)	-93.0 (0.35)	-93.9 (0.38)	-94.0 (0.34)	-95.2 (0.37)	-91.9 (0.36)	-93.8 (0.38)	-93.4 (0.34)
Binary (1 if before area change)	-736.1*** (0.00)	-742.5*** (0.00)	-736.6*** (0.00)	-741.8*** (0.00)	-740.9*** (0.00)	-746.1*** (0.00)	-739.2*** (0.00)	-744.7*** (0.00)	-740.2*** (0.00)
ln(time trend)	115.9*** (0.00)	110.1** (0.02)	115.9*** (0.00)	110.0** (0.02)	115.6*** (0.00)	109.9** (0.02)	115.7*** (0.00)	110.1** (0.02)	115.7*** (0.00)
Constant	404.2* (0.09)	404.5 (0.10)	406.5* (0.10)	402.0 (0.10)	465.5* (0.09)	462.4 (0.10)	431.0 (0.12)	428.7 (0.12)	465.4* (0.08)
Observations	192	192	192	192	192	192	192	192	192
Number of groups	9	9	9	9	9	9	9	9	9
Wald chi2	497791	814429	429806	485151	3.708e+06	1.020e+07	3.525e+06	6.820e+06	4.416e+06

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.20 Estimated Effects of Information Network (Density and Size) on Price (Complete)

Dependent Variable: Real price (yen per kg)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Revenue sharing		2.5 (0.89)		-2.8 (0.87)		-5.8 (0.77)		-3.5 (0.82)	
Network density (mean)	-9.0 (0.60)	-9.1 (0.57)							
Network density (stdev)			8.4 (0.25)	8.9 (0.16)					
Network size (mean)					25.8** (0.04)	27.0* (0.10)			22.5 (0.24)
Network size (stdev)							20.0 (0.24)	21.0 (0.23)	2.8 (0.90)
Catch in other FCAs	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.01)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)
ln(season months)	-48.6** (0.04)	-48.6** (0.04)	-56.3** (0.02)	-56.4** (0.02)	-45.4** (0.03)	-46.0** (0.04)	-53.3** (0.02)	-49.1** (0.02)	-54.2** (0.02)
Binary (1 if non jet dredges)	-119.6*** (0.00)	-119.4*** (0.00)	-109.4*** (0.00)	-108.2*** (0.00)	-116.1*** (0.00)	-115.6*** (0.00)	-110.9*** (0.00)	-111.0*** (0.00)	-110.6*** (0.00)
ln(time trend)	-212.0*** (0.00)	-212.3*** (0.00)	-205.9*** (0.00)	-205.2*** (0.00)	-212.1*** (0.00)	-211.5*** (0.00)	-206.5*** (0.00)	-206.1*** (0.00)	-206.6*** (0.00)
Constant	1,213.0*** (0.00)	1,212.0*** (0.00)	1,233.7*** (0.00)	1,239.8*** (0.00)	1,199.5*** (0.00)	1,200.2*** (0.00)	1,220.1*** (0.00)	1,215.3*** (0.00)	1,216.4*** (0.00)
Observations	225	225	205	205	225	225	205	205	205
Number of groups	10	10	9	9	10	10	9	9	9
Wald chi2	17011	30738	7688	17607	15856	39896	24413	3901	49744

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.21 Estimated Effects of Information Network (Varieties and Frequency) on Price (Complete)

Dependent Variable: Real price (yen per kg)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Revenue sharing		0.7 (0.97)		-6.8 (0.76)		-1.8 (0.94)		-15.7 (0.50)
Varieties of info shared (mean)	2.8 (0.84)	2.7 (0.86)						
Varieties of info shared (stdev)			0.7 (0.97)	1.3 (0.95)				
Frequency (mean)					-7.2 (0.46)	-7.8 (0.57)		
Frequency (stdev)							-20.6 (0.23)	-27.1 (0.24)
Catch in other FCAs	-0.0*** (0.01)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.00)	-0.0*** (0.01)	-0.0*** (0.00)	-0.0*** (0.01)	-0.0*** (0.00)
ln(season months)	-49.5** (0.05)	-49.3* (0.05)	-56.0** (0.03)	-55.9** (0.03)	-48.4** (0.05)	-48.3* (0.06)	-51.9** (0.02)	-50.1** (0.03)
Binary (1 if non jet dredges)	-118.0*** (0.00)	-117.8*** (0.00)	-112.0*** (0.00)	-110.5*** (0.00)	-117.6*** (0.00)	-117.2*** (0.00)	-109.6*** (0.00)	-106.9*** (0.00)
ln(time trend)	-211.8*** (0.00)	-211.9*** (0.00)	-206.3*** (0.00)	-205.6*** (0.00)	-211.8*** (0.00)	-211.7*** (0.00)	-206.2*** (0.00)	-204.5*** (0.00)
Constant	1,216.2*** (0.00)	1,214.5*** (0.00)	1,230.1*** (0.00)	1,228.3*** (0.00)	1,213.5*** (0.00)	1,212.1*** (0.00)	1,219.7*** (0.00)	1,216.2*** (0.00)
Observations	225	225	205	205	225	225	205	205
Number of groups	10	10	9	9	10	10	9	9
Wald chi2	18366	32953	24288	55411	12913	26474	14824	13912

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.22 Estimated Effects of Information Network (Density and Size) on Stock (Complete)

Dependent Variable: Stock density (grams per m2)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Revenue sharing		38.9 (0.67)		43.2 (0.64)		36.1 (0.68)		40.8 (0.65)	
Network density (mean)	15.9 (0.88)	12.5 (0.91)							259.1*** (0.00)
Network density (stdev)			-135.6** (0.04)	-142.1** (0.04)					-309.5*** (0.00)
Network size (mean)					44.1 (0.74)	36.2 (0.78)			
Network size (stdev)							-38.8 (0.70)	-43.7 (0.67)	
ln(season months)	-93.2 (0.35)	-94.1 (0.38)	-90.2 (0.37)	-90.7 (0.40)	-89.5 (0.36)	-91.9 (0.38)	-93.9 (0.34)	-95.3 (0.37)	-95.3 (0.33)
Binary (1 if before area change)	-737.2*** (0.00)	-742.4*** (0.00)	-736.8*** (0.00)	-742.1*** (0.00)	-733.0*** (0.00)	-739.9*** (0.00)	-737.6*** (0.00)	-743.8*** (0.00)	-742.0*** (0.00)
ln(time trend)	115.8*** (0.00)	110.1** (0.02)	115.8*** (0.00)	109.5** (0.02)	115.9*** (0.00)	110.6** (0.02)	115.8*** (0.00)	109.8** (0.02)	115.6*** (0.00)
Constant	424.6 (0.11)	420.9 (0.12)	420.8 (0.11)	416.8 (0.12)	407.1 (0.11)	408.1 (0.12)	428.1 (0.11)	426.1 (0.12)	465.0* (0.06)
Observations	192	192	192	192	192	192	192	192	192
Number of groups	9	9	9	9	9	9	9	9	9
Wald chi2	938026	1.287e+06	510392	528358	332527	697733	1.232e+06	2.648e+06	1.871e+06

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.23 Estimated Effects of Information Network (Varieties and Frequency) on Stock (Complete)

Dependent Variable: Stock density (grams per m2)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Revenue sharing		42.4 (0.64)		41.1 (0.65)		47.1 (0.61)		49.1 (0.59)
Varieties of info shared (mean)	-109.5 (0.24)	-118.2 (0.20)						
Varieties of info shared (stdev)			-54.1 (0.64)	-59.0 (0.60)				
Frequency (mean)					-121.5 (0.41)	-149.3 (0.30)		
Frequency (stdev)							149.5 (0.13)	169.7* (0.06)
ln(season months)	-95.7 (0.32)	-96.6 (0.36)	-94.9 (0.33)	-96.2 (0.36)	-96.8 (0.32)	-98.3 (0.36)	-97.1 (0.31)	-98.3 (0.36)
Binary (1 if before area change)	-735.4*** (0.00)	-741.6*** (0.00)	-737.8*** (0.00)	-744.1*** (0.00)	-738.0*** (0.00)	-744.8*** (0.00)	-739.9*** (0.00)	-746.7*** (0.00)
ln(time trend)	115.7*** (0.00)	109.5** (0.02)	115.8*** (0.00)	109.7** (0.02)	115.8*** (0.00)	108.9** (0.02)	115.7*** (0.00)	108.5** (0.02)
Constant	450.7* (0.09)	449.1* (0.10)	432.0 (0.10)	429.8 (0.11)	460.9* (0.08)	465.3 (0.10)	453.6* (0.08)	453.2* (0.10)
Observations	192	192	192	192	192	192	192	192
Number of groups	9	9	9	9	9	9	9	9
Wald chi2	493034	678803	942899	1.597e+06	1.365e+06	1.916e+06	1.053e+06	1.638e+06

Table 2.24 Estimated Effects of Various Social Capital Parameters on Price/Stock (Complete)

A.

Dependent Variable: Real price (yen per kg)			
	(1)	(2)	(3)
Unconditional (mean)	11.9 (0.37)	33.8*** (0.00)	
Trust 2	31.8** (0.02)		38.7*** (0.00)
Network size (mean)		23.8*** (0.00)	1.9 (0.87)
Catch in other FCAs	-0.0*** (0.01)	-0.0** (0.04)	-0.0*** (0.01)
ln(season months)	-37.4* (0.05)	-14.8 (0.30)	-42.0** (0.04)
Binary (1 if non jet dredges)	-123.5*** (0.00)	-125.0*** (0.00)	-119.3*** (0.00)
ln(time trend)	-212.9*** (0.00)	-214.8*** (0.00)	-212.5*** (0.00)
Constant	1,183.7*** (0.00)	1,131.4*** (0.00)	1,188.8*** (0.00)
Observations	225	225	225
Number of groups	10	10	10
Wald chi2	8243	1909	7959

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

B.

Dependent Variable: Stock density (grams per m2)			
	(1)	(2)	(3)
Unconditional (mean)	-390.5*** (0.00)	-320.6*** (0.00)	
Trust 1	215.6*** (0.01)		
Trust 2			-158.9** (0.03)
Network density (stdev)		-111.8*** (0.00)	-139.6* (0.06)
ln(season months)	-95.0 (0.32)	-95.7 (0.33)	-92.7 (0.35)
Binary (1 if before area change)	-744.8*** (0.00)	-746.0*** (0.00)	-742.0*** (0.00)
ln(time trend)	115.4*** (0.00)	115.3*** (0.00)	115.6*** (0.00)
Constant	447.4** (0.03)	490.6* (0.06)	467.7* (0.09)
Observations	192	192	192
Number of groups	9	9	9
Wald chi2	7.061e+06	6.666e+06	3.241e+06

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.25 Estimated Effects of Trust/Cooperation on Perceived Economic Outcome (Complete)

Dependent Variable: Perceptions towards economic outcome									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Revenue Sharing	0.18 (0.39)		0.32 (0.11)		0.28 (0.15)		0.24 (0.24)		0.26 (0.24)
Unconditional		0.24 (0.12)	0.24 (0.12)						
Conditional				-0.15 (0.15)	-0.14 (0.19)				
Trust 1						0.17* (0.09)	0.17 (0.11)		
Trust 2								0.01 (0.88)	0.01 (0.87)
ln(years of shellfish fishing)		0.10 (0.19)	0.13* (0.07)	0.12 (0.11)	0.14** (0.03)	0.08 (0.15)	0.11** (0.04)	0.08 (0.13)	0.11** (0.03)
ln(season months)	-0.30 (0.36)	-0.33 (0.43)	-0.18 (0.67)	-0.38 (0.42)	-0.25 (0.59)	-0.41 (0.40)	-0.30 (0.53)	-0.49 (0.32)	-0.37 (0.45)
Constant	3.60*** (0.00)	3.44*** (0.00)	2.96*** (0.00)	3.43*** (0.00)	3.02*** (0.00)	3.57*** (0.00)	3.20*** (0.00)	3.67*** (0.00)	3.27*** (0.00)
Observations	77	71	71	71	71	70	70	70	70
F	0.979	2.715	4.132	2.219	3.591	3.700	5.392	2.420	4.508
Root MSE	0.857	0.846	0.838	0.862	0.858	0.842	0.840	0.858	0.856

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.26 Estimated Effects of Information Network on Perceived Economic Outcome (Complete)

Dependent Variable: Perceptions towards economic outcome									
Revenue Sharing		0.24 (0.26)		0.34 (0.12)		0.45** (0.04)		0.23 (0.26)	0.18 (0.44)
Trust 1									0.09 (0.34)
Network density	0.17 (0.20)	0.15 (0.29)							
Network size			-0.11 (0.36)	-0.13 (0.30)					
Varieties of info shared					0.26** (0.03)	0.22* (0.05)			0.12 (0.23)
Frequency							0.38** (0.01)	0.33** (0.03)	0.26* (0.08)
ln(years of shellfish fishing)	0.07 (0.23)	0.10** (0.04)	0.08 (0.21)	0.11* (0.05)	0.13 (0.17)	0.17** (0.03)	0.12* (0.05)	0.14** (0.02)	0.14* (0.07)
ln(season months)	-0.61 (0.19)	-0.48 (0.28)	-0.48 (0.36)	-0.31 (0.53)	-0.42 (0.32)	-0.28 (0.47)	-0.14 (0.74)	-0.09 (0.83)	-0.14 (0.74)
Constant	3.90*** (0.00)	3.50*** (0.00)	3.67*** (0.00)	3.17*** (0.00)	3.43*** (0.00)	2.88*** (0.00)	3.23*** (0.00)	2.98*** (0.00)	2.98*** (0.00)
Observations	71	71	71	71	54	54	58	58	53
F	2.376	3.384	2.260	4.472	3.175	4.886	5.380	5.205	5.482
Root MSE	0.858	0.857	0.870	0.861	0.872	0.851	0.810	0.811	0.824

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.27 Estimated Effects of Cooperation/Trust on Perceived Biological Outcome (Complete)

Dependent Variable: Perceptions towards biological outcome									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Revenue Sharing	-0.02 (0.94)		-0.00 (1.00)		-0.02 (0.93)		-0.05 (0.84)		-0.05 (0.83)
Unconditional		0.05 (0.60)	0.05 (0.61)						
Conditional				-0.13 (0.33)	-0.13 (0.32)				
Trust 1						-0.07 (0.65)	-0.07 (0.65)		
Trust 2								-0.10 (0.18)	-0.10 (0.18)
ln(years of shellfish fishing)		0.11 (0.39)	0.11 (0.41)	0.12 (0.36)	0.12 (0.39)	0.09 (0.44)	0.09 (0.48)	0.09 (0.41)	0.09 (0.45)
ln(season months)	-0.31 (0.26)	-0.26 (0.41)	-0.26 (0.39)	-0.21 (0.58)	-0.22 (0.54)	-0.34 (0.33)	-0.36 (0.24)	-0.31 (0.37)	-0.34 (0.27)
Constant	3.83*** (0.00)	3.44*** (0.00)	3.44*** (0.00)	3.33*** (0.00)	3.36*** (0.00)	3.56*** (0.00)	3.63*** (0.00)	3.52*** (0.00)	3.60*** (0.00)
Observations	77	71	71	71	71	70	70	70	70
F	0.730	0.608	0.789	2.122	7.168	0.468	0.476	1.058	1.043
Root MSE	0.868	0.892	0.899	0.884	0.891	0.877	0.884	0.874	0.880

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.28 Estimated Effects of Information Network on Perceived Biological Outcome (Complete)

Dependent Variable: Perceptions towards biological outcome									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Revenue Sharing		0.03 (0.91)		0.02 (0.93)		0.10 (0.73)		-0.08 (0.77)	0.01 (0.97)
Trust 1									-0.13 (0.49)
Network density	-0.06 (0.71)	-0.06 (0.68)							
Network size			-0.09 (0.32)	-0.09 (0.37)					
Varieties of info shared					0.32* (0.07)	0.31* (0.08)			0.24 (0.11)
Frequency							0.19 (0.13)	0.21** (0.05)	0.11 (0.30)
ln(years of shellfish fishing)	0.12 (0.29)	0.13 (0.29)	0.09 (0.43)	0.10 (0.44)	0.11 (0.38)	0.12 (0.33)	0.07 (0.62)	0.06 (0.66)	0.08 (0.47)
ln(season months)	-0.25 (0.47)	-0.23 (0.42)	-0.29 (0.40)	-0.28 (0.37)	-0.40 (0.28)	-0.37 (0.34)	-0.27 (0.49)	-0.29 (0.45)	-0.48 (0.33)
Constant	3.37*** (0.00)	3.33*** (0.00)	3.52*** (0.00)	3.49*** (0.00)	3.62*** (0.00)	3.50*** (0.00)	3.66*** (0.00)	3.75*** (0.00)	3.80*** (0.00)
Observations	71	71	71	71	54	54	58	58	53
F	0.674	0.493	0.747	0.864	6.779	4.362	1.485	3.776	11.74
Root MSE	0.892	0.898	0.889	0.896	0.881	0.889	0.915	0.922	0.887

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.29 Estimated Effects of Types of Information Shared on Perceived Economic Outcome (Complete)

Dependent Variable: Perceptions towards economic outcome						
	(1)	(2)	(3)	(4)	(5)	(6)
Revenue sharing		0.59** (0.03)		0.62** (0.02)		0.63** (0.01)
Specific hot-spots	0.19* (0.09)	0.21* (0.07)			0.17 (0.12)	0.18* (0.09)
High gear density areas			0.18** (0.03)	0.21** (0.01)	0.17** (0.05)	0.20** (0.03)
Number of relationships reported	-0.13 (0.10)	-0.18* (0.07)	-0.09 (0.33)	-0.14 (0.10)	-0.15* (0.06)	-0.20** (0.02)
ln(years of shellfish fishing)	0.13 (0.16)	0.19** (0.04)	0.14 (0.12)	0.20** (0.03)	0.16 (0.11)	0.23** (0.02)
ln(season months)	-0.58 (0.23)	-0.35 (0.31)	-0.50 (0.31)	-0.25 (0.52)	-0.54 (0.26)	-0.29 (0.41)
Constant	4.22*** (0.00)	3.59*** (0.00)	3.94*** (0.00)	3.25*** (0.00)	4.16*** (0.00)	3.48*** (0.00)
Observations	54	54	54	54	54	54
F	2.227	3.181	4.044	9.621	3.760	9.614
Root MSE	0.894	0.853	0.891	0.845	0.888	0.838

Robust pval in parentheses

*** p<0.01, ** p<0.05, * p<0.1

MANUSCRIPT – 3

Do Management Systems Foster Social Capital? Empirical Evidence from

Japanese Surf Clam Fisheries

In preparation for journal submission

by

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Do Management Systems Foster Social Capital? Empirical Evidence from Japanese Surf Clam Fisheries

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Abstract

We empirically examine the social effect of management systems. We focus on a particular management practice employed in self-governed coastal fisheries in Japan—revenue sharing arrangement. We hypothesize that management systems affect cooperative relationships and information network in a community; broadly termed as social capital. We quantified social capital using controlled economic experiments with fisherman subjects as well as surveys. Using wild cluster bootstrap for small sample inference, we find evidence of the positive effect of revenue sharing on information network possibly because revenue sharing arrangement provides disincentives to compete and accompanies synchronized collective fishing operation. Interestingly, revenue sharing fishers are no more likely to cooperate unconditionally (i.e., unilaterally) and furthermore they are less likely to cooperate conditionally (i.e., only if others cooperate).

Keywords: information network, cooperation, partnership, fishery cooperatives

3.1 Introduction

While the primary assumption in economics is that every agent is motivated by self-interest, importance of immaterial motivations such as moral, reputation, and values in economic decision-making has been recognized for a long time. From Adam Smith to Amartya Sen, the vast literature stressing importance of immaterial, unselfish motivations (e.g., so-called ‘warm-glow’) exists. In fact, many attempts to incorporate immaterial motives in an economic model have been made (e.g., Andreoni, 1989; Bowles & Polanía-Reyes, 2012; Fehr & Schmidt, 1999; Gaspart & Seki, 2003). In what follows, we examine the possibility of nurturing such motivations in a form of social capital. In particular, we focus on understanding how social capital can be fostered in a commons dilemma, a typical example of market failure when the costs and/or the prices do not convey all information. Its understanding is not only important but also relevant in policy discussion to help us achieve ultimately better economic outcomes.

More recent studies on environmental policies highlight the reasons why more attention should be paid to immaterial motives when designing a policy. Behavioral response to monetary incentives sometimes does not align with regulator’s intention as referred as crowding out (Cardenas, Stranlund, & Willis, 2000). In the worst-case scenario, economic incentives induced by an institutional setup may undermine individual voluntary motivation to contribute to a better world that would have prevailed otherwise (Bowles & Polanía-Reyes, 2012; Carlsson & Johansson-Stenman, 2012). In particular, in a social dilemma situation such as a fishery each harvester may contribute to the group interest because of moral or reputation among harvesters (e.g.

Bénabou & Tirole, 2006; Brekke, Kverndokk, & Nyborg, 2003; Gaspart & Seki, 2003). Trust or reciprocity among members, or social norms can support individual motivation to make sincere commitment to a group interest in a closed society. These studies suggest that non-monetary incentives can play an important role in ensuring success of implementing a policy.

Non-monetary incentives discussed above comprise many aspects of social capital. Social capital is a concept that attributes such as trust, cooperation, and reciprocity among people, and norms and networks in a community are important in improving economic life (Fukuyama, 1996; Putnam, 2001). A stream of the literature on the commons has highlighted important roles of social capital in a community that self-governs a community resource (e.g. Ahn & Ostrom, 2008; Bowles & Gintis, 2002; Gutiérrez, Hilborn, & Defeo, 2011; Pretty, 2003).

Formal economic institutions—markets and property rights—have been recognized as fundamental in determining organizational as well as national economic success (Acemoglu, Johnson, & Robinson, 2005; North, 1973, 2005; Williamson, 1975). As Acemoglu et al. (2005, p. 397) state: “differences in economic institutions are the fundamental cause of different patterns of economic growth.” Different economic institutions induce various incentives for people to innovate, to invest, to save for the future, and to provide public goods, which results in differences in economic success. They not only determine the size of a pie but also how a pie should be distributed.

Needless to say the same argument applies to management of the commons. Institutional arrangements inside and outside of the commons influence how

successfully resource users can manage the resource and thus benefit from their own resource use (Baland & Platteau, 1996; Ostrom, 1990; Wade, 1989). Whether or not access to the resource is restricted to a limited number of users can alter the incentives for conservation and thus the resulting economic outcomes. Similarly establishment of any types of property rights for resource usage can mitigate some of the externality causing rent dissipation in the commons and improve economic efficiency.

Another stream of the literature suggests that economic institutions do more than changing economic incentives and distributing goods and services; they also affect the accumulation of social capital. Bowles (1998, p. 75) argues that they “also influence the evolution of values, tastes, and personalities” based on cases drawn from experimental economics, history, and other social sciences. Bowles (1998) also points out that moral, ethics, or personality matters especially in the cases of incomplete contracting and asymmetric information, which are prevalent in the real world including many commons situations.

The hypothesis that economic institutions affect social capital can provide important policy implications, because the level of social capital has been shown to be associated with economic performance. In fact, Carpenter and Seki (2011) showed a strong correlation between fishermen’s propensity to cooperate (one aspect of social capital) and fishing productivity. Social capital is also found to be empirically associated with economic productivity in other workplace (e.g. Barr & Serneels, 2009; Bouma, Bulte, & van Soest, 2008; Carter & Castillo, 2002; Karlan, 2005; Knack & Keefer, 1997).

In this paper we empirically test the hypothesis that social capital can be

fostered by formal economic institutions. In other words, differences in the levels of social capital in a fishing community can be explained by differences in management systems governing fisheries. In so doing we rigorously quantify the effect of management systems on accumulation of social capital.

To test the hypothesis, we focus on a particular management system employed in a fishery—revenue sharing arrangement—as our empirical case study. Revenue sharing arrangement is a type of management rule in a fishery, in which harvesters share catch and/or profits among the members of a fishery cooperative. Employment of such arrangement is a collective action that a group of harvesters takes. The economic roles of revenue sharing in fishery management have been examined in the literature (e.g. Gaspart & Seki, 2003; Platteau & Seki, 2001; Uchida & Baba, 2008). To our knowledge this study is the first to investigate the consequence of revenue sharing arrangement on social aspect of a community and empirically quantify the effects.

This paper provides the quantitative effect of management systems—whether the group has employed revenue sharing or not—on the social aspect of a community (social capital). In particular, this paper asks whether a difference in management systems can result in different cooperative relationships and different information networks in a community. This paper provides the first rigorous analysis to measure the effect of different management systems on social capital and provides insights into an effective policy that can be employed for development of social capital.

The data were collected from Japanese fisheries, many of whom operating under revenue sharing have been successfully managing the resources as well as

generating resource rents (Platteau & Seki, 2001; Uchida & Baba, 2008). For the purpose of this paper, social capital is narrowly defined as cooperation and information network, as these are most relevant to fishing operation as a community. To quantify cooperation, controlled economic experiments with fishermen subjects were conducted. As for information network, indices are constructed from survey responses of the same fisherman subjects. Wild cluster bootstrapped p-value method for small sample inference was then used to rigorously quantify the effect of revenue sharing.

Revenue sharing arrangement can be an alternative management practice to solve problems in common-pool resource management that cannot be resolved by other emerging management tools such as Individual Transferable Quota (ITQ). While it can mitigate the externality in a fishery resulting from the common property nature, the ITQ, which was first suggested by Christy (1973), often fails to overcome excessive competition across spaces and times, let alone political difficulty in implementation (Boyce, 1992; Copes, 1986). Revenue sharing arrangement can be one of a few systems to foster cooperation and information sharing in a fishery; it can provide cause for a group and can encourage a cooperative environment for fishing rather than competitively fishing only for self-interests.

3.2 Japanese surf clam fishing in Hokkaido Prefecture

Any entities that conduct commercial fishing in Japan's coastal waters must belong to a local Fishery Cooperative Association (FCA). These FCAs not only enforce national and prefectural regulations but also self-regulate the resources tailored to local

conditions. Within an FCA many groups of fishers are formed mainly based on the species they target and/or the fishing gear they use. Each group has their own rules of regulation and management and can decide whether to share revenue.

Based on the data provided by Uchida and Wilen (2007), many of the revenue-sharing groups are concentrated in the northeastern Japan, target sedentary species, and use small-scale trawl or gillnets. The coastal fisheries in southern Japan are characterized with fishing many species with the same fishing technology, which complicates the process to share revenue. Many sedentary species fisheries are required to employ small-scale trawl and gillnets by regulation, which results in relatively smaller heterogeneity in fishing skills and outcomes compared to other migratory species or other fishing technology such as fishing bonito. According to Fishery Census of Japan, the fishing groups that share revenue accounted for 11 percent of all groups in Japan in 1988 and the percentage increased to 17 percent until 1998, in which consistent data are available.¹

We chose the Japanese/Sakhalin surf clam (*Pseudocardium sachalinensis*) fishery, known as Hokkigai in Hokkaido Prefecture, for this study for several reasons. There are a sufficient number of groups engaged in this fishery in the same Hokkaido Prefecture. There are also sufficient variations in with or without revenue sharing while relatively homogeneous in other operational rules.

Focusing on a particular region and carefully selecting groups based on the data from Uchida and Wilen (2007), but without controlling the outcomes, enables us to control many observed and possibly unobserved characteristics at the time of

¹ In 2003 the ratio of revenue sharing among all groups dropped to 12% partly because the definition of fishing groups was changed. In later censuses no comparable information has been provided.

sampling. Harvesting technology is another factor controlled at the time of sampling. For many years all sampled fishery groups employ the jet dredges, by far the most common and the most advanced technology for harvesting the surf clams.

The way the FCAs in Hokkaido organize their shellfish fishery is practically identical. It involves (1) stock assessment conducted by the staff members at Fisheries Extension Offices located all over Hokkaido in collaboration with the local skippers and FCAs, either prior to or after every fishing season; (2) all skippers are called to gather for a pre-season meeting to hear the results of the stock assessment from the local Fisheries Extension Office, to decide a Total Allowable Catch (TAC) for the coming season, and to review operational rules and policy for the season; and (3) during the season a leader and sub-leaders closely watch the market prices (mostly by directly talking with the middlemen) and decide whether to go fishing on the day and if so how much to land subject to the seasonal TAC.² Each group usually has an elected leader and multiple sub-leaders for the groups of a significant size. Finally, (4) during and/or after the season whether they share revenue or not all skippers in all FCAs are required to contribute to the collective efforts to make the fishery favorable for growth of the Japanese surf clams although how much to contribute can vary across the FCAs. These efforts include cultivating ocean beds, removing predators, and transplanting clams. Many FCAs also buy juvenile clams from other fisheries and release them in their waters.

The sample consists of ten fishery groups, five of which are under revenue sharing and the other five are not and have never been under such arrangement. They

² Individual skippers can decide whether or not to fish on the day a leader decides to go fishing, but they cannot go fishing when the leader decides not to go. On the other hand, when a group shares revenue, skippers must follow a leader's decision; all skippers fish or do not fish altogether.

all engage in a small-scale trawl fishery, targeting the Japanese surf clams, and are located in Hokkaido prefecture (eight of them are in Kushiro/Nemuro region, eastern Hokkaido), which means facing the same market, biological conditions, and historical backgrounds. All the groups self-manage the resources of the Japanese surf clams as detailed above; they voluntarily set a TAC based on the stock assessment; they perform the collective efforts for stock enhancement such as stocking and transplanting. All fishers, regardless of management systems, depart from their ports at the sunrise (regulation set by the government), but only revenue sharing fishers return to the ports all together at the same time. Some revenue sharing fishers designate themselves to specific fishing grounds prior to departure and communicate over the radio on the sea about who catch how much in where, further adjusting effort allocation on the sea. In other words, the sampled groups are only different in a decision to employ revenue sharing arrangement accompanied by collective fishing operation in major management/operational rules, but the degree of self-regulation can differ across the FCAs.

The fishers under revenue sharing are financially motivated to coordinate allocation of fishing efforts in both spatial and temporal dimensions; collective fishing operation financially supported by revenue sharing arrangement can further facilitate development of social capital in a fishing community. On the other hand, the non-revenue sharing fishers do not have such an incentive because their profits solely depend on their own catch and the benefits of effort allocation may not accrue to all the fishers equally. The non-revenue sharing fishers do still need to interact with each

other in fishing operation as a member of the FCA, but the interaction is not financially motivated.

3.3 Methods

We collected this unique dataset containing 79 observations from ten fishery groups in Japan. The dataset consists of individual social capital parameters, each of which will be regressed on a group management indicator—whether sharing revenue or not—and other individual demographic variables for controls.

Although social capital involves various attributes, the focus in this study is on cooperation measured by controlled economic experiments with fishermen subjects and information network measured by the survey. Use of experimental method to measure traditionally hard-to-measure variables such as social capital has been advocated in previous studies (Camerer & Fehr, 2004; Cardenas & Carpenter, 2005; Carpenter, 2002), and in fact many applications exist (e.g., Barr & Serneels, 2009; Bouma, Bulte, & van Soest, 2008; Carpenter, Bowles, Gintis, & Hwang, 2009; Carpenter & Seki, 2011; Carter & Castillo, 2002; Karlan, 2005). Glaeser et al. (2000) carefully compared the experimental method with the survey method and concluded that experiments could be combined with surveys to supplement to each other.

First we detail construction of cooperation parameters with the experiment and then construction of information network indices with the survey. Then, we introduce empirical strategy to estimate the outcome variables (social capital parameters) with our variable of interest (a group management variable).

Cooperation parameters

To measure cooperation among fishermen the standard, repeated Voluntary Contribution Mechanism (VCM) was conducted (Camerer & Fehr, 2004; Carpenter, 2002). Participants were recruited through the FCAs, and many of them held some executive positions in the fishery groups at the time of recruitment. A flyer was provided with the FCAs to make general calls for the experiments and the surveys, and the flyer indicated that the volunteers would be asked to participate in economic experiment (play a simple game) in addition to a survey on fishing operation and they would be paid in cash fixed participation fees plus the earnings from the experiment.

Before the experiment began participants were randomly divided into groups of four persons that were sustained for an entire session. The participants were not told whom they were playing with.³ The participants were given 3,000 yen (roughly US\$30) worth of coins as an endowment every round and asked how much to contribute to a public good from his endowment. Once all the participants made their decision the total contribution of each group was calculated, doubled by the experimenter, and then distributed equally among the group members. The amount not contributed to a public good was kept to the participants. The participants earn a sum of the dividends from a public good, regardless of their own contribution to a public good, and the money kept to themselves for a round. The dominant strategy in the game is to contribute nothing because marginal return from a public good is smaller than the one from a private account regardless of total group contribution. The game

³ In case that the number of participants was not multiple of four, which happened at most sessions, the contribution amounts of some participants were counted twice in multiple groups to avoid the effect of varying group size as in Carpenter and Williams (2010).

was repeated ten times with the exception of one session.⁴ At the end of the experiment two of the ten rounds were randomly drawn as a binding round and the participants were paid the average of the payoffs from the two rounds plus a participation fee of 3,000 yen.⁵

All the sessions took place in a conference room at the FCA or at the community center nearby. The participants were seated facing the wall, and in between the participants portable blinds were constructed (Figure 3.1). At the beginning of every round the participants were given three boxes in different colors. In a yellow box were 3,000 yen worth of coins—real money—as an endowment, a red box was intended for a private account, and a green box was for public good contribution. The participants were asked to move all the coins from the yellow box to either the red box (to keep) or the green box (to contribute), which made it difficult to guess what other participants were doing based on the amount of the noise made from moving coins. Once all the participants made their decision the experimenters collected all the boxes and calculated the total contribution of each group and the dividends from a public good. These results were written down on a sheet of paper and distributed to the participants with the three boxes and the coins for the next round.

⁴ The last five rounds were conducted with social disapproval treatment introduced by Carpenter and Seki (2011). However, in this study we do not consider the parameters obtained by this treatment although the observations during these rounds are used for estimation. The session at one FCA repeated the standard VCM for six times with another version of social disapproval for the last two rounds.

⁵ A participation fee was set high in this experiment to mitigate concern expressed by many FCA staffs for performance-based payment. The experiment accommodated two more games for different research and thus the session lasted between 2.5 hours and 3 hours. The voluntary contribution mechanism lasted less than 1.5 hours and the average earning from this game was 4,700 yen.

A total of 80 fishermen participated in the experiment; two subjects were excluded from the analysis.⁶ Table 3.1 shows summary statistics of participants. One⁷ to 16 skippers from each FCA that ranges from 12 to 100 percent of all member skippers participated in a session (Table 3.2). As expected, the smaller the FCAs are the more comprehensive the sampled participants are. How representative the sample is uncertain because of unavailability of information on non-participants in the same FCA. The FCAs greater than ten targeted the skippers who held some positions in the group at the time of the experiments in addition to general calls directed towards all members because these skippers would feel more obligated to cooperate for research. The bottom line is that selection of the participants was done similarly across the FCAs of a lower participation rate.

The mean contribution of all participants is 1,635 yen (55% of endowment) with individual contribution ranging from zero to 3,000 yen (0-100% of endowment). Revenue sharing fishers on average contributed 1,600 yen (53%) to a public good, compared with the average contribution by non-revenue sharing fishers of 1,762 yen (59%). The difference is statistically significant at $p\text{-value} = 0.004$ (Mann-Whitney-Wilcoxon test). However, this does not necessarily imply that revenue sharing-fishers cooperate less because in the sample they are statistically significantly younger than

⁶ One subject was a FCA staff and did not face the same incentive as other subjects. He did not expect to receive any compensation during the experiment and planned to surrender it to his supervisor. He was needed in the session because only four fishers showed up, which would identify exactly whom they were playing the game with. Difference in the degree of anonymity potentially alters the incentives because the participants know each other. The other subject was an elderly skipper who contributed all of his endowment throughout the session. At the end of the session he gave his earnings to his grandson who worked at the FCA. It is apparent that he did not take a series of decisions seriously. The average contribution made by the other three members in the group with the FCA staff was smaller than the rest of the participants and the average contribution in the group with the elderly skipper was greater, and these two groups (excluding the FCA staff and the skipper) are significantly different from the rest of the participants at $p\text{ value} < 0.01$ respectively.

⁷ One participant from one FCA attended the joint session with another FCA.

non-revenue sharing fishers, which is a very important demographic characteristic that can affect how much to contribute (Aswani, Gurney, Mulville, Matera, & Gurven, 2013). In fact, significant difference between the two groups disappears after controlling for age.⁸ For comparison, the same experiment by Carpenter and Seki (2011) with fisherman subjects yielded the overall average contribution of 49% (N = 27) with revenue sharing fishers contributing 51% and non-revenue sharing fishers contributing 46%. This suggests that the fishermen in our study contributed slightly more overall regardless of management systems and the difference in contribution between revenue sharing fishers and non-revenue sharing fishers went in the opposite direction.

The observed amount contributed to a public good, y , in round t by subject i in session j is censored between zero and 3,000 and is related to a latent variable, y^* , as follows.

$$y_{ijt} = \begin{cases} 0 & \text{if } y_{ijt}^* \leq 0 \\ y_{ijt}^* & \text{if } 0 < y_{ijt}^* < 3000. \\ 3000 & \text{if } y_{ijt}^* \geq 3000 \end{cases}$$

The amount contributed to a public good, y , is regressed on a sum of contribution made by other members in the previous round, $\mathbf{X}_{-ij(t-1)}$. The model needs to allow individual variation for this coefficient for the reason to be apparent later and thus accommodates a random parameter for $\mathbf{X}_{-ij(t-1)}$. In addition, it is likely to be

⁸ The OLS without controlling for age ($\text{Contribute}_{ijt} = \alpha + \text{Rev.Sharing}_j + e_{ijt}$; Adjusted R^2 for the model is 0.009) implies that revenue sharing skippers contribute on average 202 yen less than the average non-revenue sharing skipper at p value=0.006 while the OLS controlling for age ($\text{Contribute}_{ijt} = \alpha + \text{Rev.Sharing}_j + \text{age}_i + e_{ijt}$; Adjusted R^2 for the model is 0.040) does not find significant difference between the two groups (p value=0.204). Multilevel modeling incorporating random effects of individuals nested within sessions also yields similar results; revenue sharing is not a significant factor (p value=0.431) when age is controlled for (Wald statistics for the model is 6.73).

correlated within the same subject nested within the same session and thus the two random effects for subjects and for sessions are also estimated.

We estimated this model using Generalized Latent Variable Model (Skrondal & Rabe-Hesketh, 2004). This model is very flexible that it estimates multi-level random effects as well as one random parameter while allowing the Tobit specification simultaneously. The model is estimated with the following specification.

$$\Gamma\{E(y_{ijt}|\mathbf{X}, \mathbf{u})\} = \beta_0 + \beta_1 \mathbf{X}_{-ij(t-1)} + u_j^1 + u_{ij}^2 + u_{ij}^3 \mathbf{X}_{-ij(t-1)},$$

where β_0 and β_1 are parameters to be estimated, $\mathbf{X}_{-ij(t-1)}$ is a vector of a sum of contribution made by other members in the previous round, u_j^1 and u_{ij}^1 are random effects for sessions and subjects, u_{ij}^3 is a random parameter, $\Gamma(\cdot)$ is a link function (the identity or the probit function), and y_{ijt}^* is distributed as Gaussian or Bernoulli. We assume

$$E(y_{ijt}|\mathbf{u}) = \Gamma^{-1}(\beta_0 + \beta_1 \mathbf{X}_{-ij(t-1)} + u_j^1 + u_{ij}^2 + u_{ij}^3 \mathbf{X}_{-ij(t-1)}).$$

Table 3.3 shows estimation results of the model. An average participant contributes 1,272 yen and an individual variation is in a range of 998 yen standard deviation, which is both economically and statistically significant. An average participant contributes 0.06 yen (the average marginal effect on the observed distribution) more to a public good after observing a marginal increase in the contribution by the other members, which is statistically significant but not economically significant. This varies across individuals in a 0.08 yen standard deviation at a statistically insignificant level.

The results suggest that the participants care about what the others' contribution is and do respond to it cooperatively. The positive coefficient for β_1

implies that they do not shirk and cooperate more when the others cooperate more.

However, a dominant part of their strategies is their own contribution level determined outside of what the others did in the previous round. The participants are a group of people who interact daily or at least regularly in a fishery regardless of their management systems. It is possible that they decide their contribution based on the relationship they have in a daily life rather than on what the other participants did in this experiment. This is captured in β_0 and its variation across individuals as u_{ij}^2 .

The two parameters for cooperation are created: conditional cooperation and unconditional cooperation (Carpenter & Williams, 2010; Carpenter & Seki, 2011). The conditional cooperation parameter takes a value of u_{ij}^3 and measures how cooperative a person is in response to observed cooperativeness of the other members. A greater value of this parameter indicates that a person is willing to cooperate more after knowing the others' cooperation than an average subject in the sample. The unconditional cooperation parameter takes a value of u_{ij}^2 and measures general cooperativeness of a person after taking into account conditional cooperation. The greater the value of this parameter, the more cooperative a person is independently from what the others are doing. Table 3.4 shows summary statistics of the two parameters that are normally distributed by assumption.

Information network indices

Participants completed a survey for demographics and answered questions on information network among fishermen such as the number of other fishermen they

exchange information with. The indices for information network are constructed from these survey responses.

Based on the work by Holland et al. (2010) and Holland et al. (2013), we construct the measures of information network a skipper has in the shellfish fishery (Table 3.5). The size of information network is constructed by the survey response to the question asking the number of shellfish fishermen with whom to have shared important information that potentially affected own profits from shellfish fishing during the fishing season in 2012. An average skipper in these fishery groups shared such information with ten skippers. Normalizing the size by the possible number of relationships (the size of a fishery group) yields density of information network. An average density was about 30 percent, ranging from 0 to 100 percent. This indicates, for example, in the case of the fishery group comprised of ten fishermen an average fisherman would have shared important information with three other fishermen.

After listing five names of fishermen with whom a person has most important relationships, participants were asked what kinds of information they shared with each of the relationships.⁹ Based on the information provided by FCA staff, six kinds of information were identified as relevant to the surf clam fishery: market, buyer information, specific hot-spots, market for bycatch and its hot-spots, high gear density areas, and boat and gear. Taking the average of the number of kinds of information a person shared with the listed relationships produces an index for varieties of information exchanged. An average fisher shared about two types of information.

Among the six kinds the information on specific hot-spots was shared most, followed

⁹ Some skippers refused to provide the names of other skippers because they feel that they would leak personal information of others, which resulted in a lower response rate for the subsequent questions on varieties of information and frequency of sharing the information than the other questions.

by market information (Figure 3.2). Information on boat and gear is also important in these fisheries as reflected by the rule of many FCAs that more than one skipper¹⁰ are required to fish in one boat. These fishermen regard other fishermen as being close friends (49%) and having common in boat and gear (33%).

Frequency of sharing the six types of information listed above during a 2012 season was asked for each relationship in a scale of one to seven: 1 as frequent as everyday, 2 as every few days, 3 as once per week, 4 as once every two weeks, 5 as once per month, 6 as every two months, 7 as once during the season. An average skipper shared the important information with other skippers at least once a week during the season. To avoid confusion, the reverse coded index will be used for main estimation for frequency.

Empirical estimation

We are interested in estimating the effect of revenue sharing on each parameter/index for social capital defined above. Estimation will provide empirical evidence of how management systems affect social aspect of a fishing community. It will also clarify what aspect of a fishing community management system can and cannot influence.

Each parameter of social capital is taken as a dependent variable in a separate OLS regression. In all regression models, standard errors are estimated with cluster robust variance estimator and then are bootstrapped with the wild cluster bootstrap (Cameron, Gelbach, & Miller, 2008). The variable of interest is a binary variable taking 1 if a fisher is under revenue sharing and 0 otherwise. Other variables for

¹⁰ A term 'skipper' used in this study means a fisher who is independent and not hired for a fixed remuneration by a captain. Therefore a skipper may jointly own a boat or pay a fixed charter fees to an owner.

controls in the model include demographic information of fishers: log of age, the number of persons in the household, education levels, and log of the number of years in shellfish fishing.¹¹

One may argue that the OLS estimates suffer from selection bias. While revenue sharing can affect social capital parameters, social capital could influence the decision for a fisher to select into a revenue sharing group. Carpenter and Seki (2011) discussed that the selection bias for revenue sharing as an individual decision is not a significant problem in Japanese fisheries because each fisher did not self-select into the system. While individual decisions to adopt revenue sharing may not possess selection bias observed in selecting into job training, adoption of revenue sharing arrangement is possibly nonrandom. Preferences, value, and experience of individual fishers have been likely to affect the group decision to adopt revenue sharing. Suenaga (2008) emphasized the importance of involving fishers in the decision making process in Sandfish fishery in Japan. All the fishers surveyed in the Japanese surf clam fishery who gave valid response (64% of the respondents) suggested some involvement in the process for a change in operational rules in the fishery.

One may also argue that the OLS estimates are biased due to endogeneity. There may exist another mechanism that can influence the decision to employ revenue sharing while correlated with unobservables captured in the error term. One possible scenario is a catastrophic event in a shellfish fishery such as depletion of the resource due to overfishing, disease, weather, or all combined. Careful examination of background information suggests that this is not the case. First, we asked in the survey

¹¹ Correlation between these variables is not a concern. Age and shellfish experience are most correlated and their correlation coefficient is 0.57.

whether they have seen the shellfish resources depleted or drastically decreased. After dropping 13 individuals who have been in the fishery for less than 10 years, we found 71 percent of revenue sharing fishers answered “yes” to the question while 72 percent of non-revenue sharing fishers did, which is not a statistically significant difference (Mann-Whitney-Wilcoxon test, p value = 0.63). We also examined a numerical measure of resource stock density over the last 20 years or so (Figure 3.3). The mean density of revenue sharing groups was 0.59 kilograms per squared meter of fishing grounds and the mean density of non-revenue sharing groups was 0.54. We found these distributions between the two groups not statistically significantly different (Mann-Whitney-Wilcoxon test, p value = 0.61). This can be also supported by the fact that all the fishery groups, regardless of management systems, have been self-imposing a TAC for the last 20 years at least.

Causal inference of the estimates crucially depends on how well unobserved heterogeneity is controlled because occurrence of revenue sharing arrangement is possibly nonrandom. The sampled fishery groups have been controlled on some important observables at the time of sampling; some relevant characteristics of individual fishers will be controlled in a regression. Unobservables consist of a part that is correlated with observables and a part that is uncorrelated. The estimates are valid to the degree of how closely related the observables are to the unobservables and thus how well these observables capture unobserved heterogeneity.

Concerns for standard errors still remain. The small sample problem of ten fishery groups can understate the standard deviation of the OLS estimators. The literature has been casting doubts on inference based on cluster-robust standard errors

when they are applied to the data containing a few clusters and the invariant variables of interest within a cluster (Angrist & Lavy, 2009; Bertrand, Duflo, & Mullainathan, 2004; Donald & Lang, 2007). Asymptotic justification of cluster-robust standard errors relies on the assumption that the number of clusters goes to infinity. Clearly, the data with ten clusters (groups) do not meet this assumption.

Although several solutions have been proposed, the wild cluster bootstrap analyzed in Cameron et al. (2008) is the most appropriate in this study. The wild cluster bootstrap is different from the standard bootstrap method with cluster option commonly implemented by statistical software such as Stata or SAS. The wild cluster bootstrap can overcome the problems with having a few clusters and invariant variables within a cluster by forming pseudo-samples based on the residuals and using “asymptotically pivotal” statistic. A statistic is said to be asymptotically pivotal if its asymptotic distribution does not depend on any unknown parameters. With a few clusters this feature is crucial. While the standard bootstrap directly evaluates the distribution of the OLS estimates, the wild cluster bootstrap forms the Wald statistics for every pseudo-sample and evaluates the distribution of these Wald statistics, which is asymptotically pivotal.

The wild cluster bootstrap also solves the issue with invariant variables within a cluster, which can be an issue with the standard bootstrap with cluster option. In forming pseudo-samples the wild cluster bootstrap does this based on residuals not on pairs of a dependent variable and explanatory variables, which have a good chance of replicating the same pseudo-samples if explanatory variables do not vary within a cluster.

Cameron et al. (2008) recommend to implement the wild cluster bootstrap with the null hypothesis imposed. Instead of using two-point distribution originally applied by Cameron et al. (2008), Webb (2014) proposes to use six-point distribution, which is recommended especially for the data with a very few clusters, say less than 10 clusters. This can greatly increase the number of possible values of the estimated Wald statistics from pseudo-samples.

Another method, bias-reduced linearization (BRL) originally proposed by Bell and McCaffrey (2002) and applied by Angrist and Lavy (2009), can also achieve asymptotic refinement. However, it is not suitable with the data in this study as underlying heteroskedasticity is likely to be severe due to unbalanced clusters. Monte Carlo simulations in Cameron et al. (2008) show that when there is heteroskedasticity, BRL no longer improves inference whereas the wild cluster bootstrap still does.

3.4 Results

Overall we find that the implementation of revenue sharing affects formation of some aspects of social capital (Table 3.6). In particular, revenue sharing arrangement has a negative impact on conditional cooperation while it has a positive impact on information sharing among fishers.

First, we hypothesized that revenue sharing arrangement enhances cooperative relationship among fishers; the relationship fishers face in daily fishing operation, which can significantly depend on whether fishers are under revenue sharing arrangement, may force the fishers to be unconditionally and conditionally cooperate with each other. Interestingly, the results show that revenue sharing arrangement does

not influence unconditional cooperation among fishers but does influence conditional cooperation negatively (Table 3.6). This implies that revenue sharing fishers are no more likely to cooperate unconditionally although revenue sharing arrangement seems to require greater cooperation among fishers. In addition, the negative sign of conditional cooperation among revenue sharing fishers suggests that the fishers under revenue sharing are not only uncooperative to the group but also they are less likely to cooperate even when they see the others contributing to the group. In addition, the degree of uncooperativeness in conditional cooperation (the conditional average difference in conditional cooperation between revenue sharing fishers and non-revenue sharing fishers) is significant considering the range of the estimated variance of the parameter. However, it should be noted that an overall explanatory power of conditional cooperation was found to be trivial from the earlier examination in Section 5.3.

Second, we find evidence of the effect of revenue sharing on information network (Table 3.6). Although revenue sharing does not necessarily increase or decrease network density and network size, it does increase the varieties of information shared and frequency of sharing such information. The fishers under revenue sharing share on average 0.6 more varieties of information than non-revenue sharing fishers and they share such information much more frequently. The estimated effect of 2.02 in a scale of frequency can be interpreted as an increase in frequency from every two weeks (-4) to every two days (-2). An average fisher in the sample shares two kinds of information about a fishery with information on specific hot-spots being most likely and the market information the second most likely. In addition to

these two kinds of information an average revenue sharing fisher is more likely to share the information on boat and gear while non-revenue sharing fisher on average shares two kinds out of these varieties. This may reflect the fact that revenue sharing fishers operate fishing together as a group, which can require more detailed information about what other group members are doing being shared amongst them. The collective daily fishing operation, contribution to which can be aligned with self-interest under revenue sharing arrangement, can motivate fishers to communicate more frequently with each other and to share more information. Interestingly, revenue sharing arrangement does not seem to affect the absolute size of information network or the normalized size of the network.

The wild cluster bootstrap yields the same significance level of the estimates as the cluster robust standard error p value. Thus, the inference of significance of the estimates remains the same even after correcting for the small sample. These results are consistent with the results obtained by BRL, which was discussed as another method to address with small sample inference.

3.5 Discussion

Economic institutions can influence what social relationships people in a community have beyond their realm of economic outcomes. In this paper we examine how different management systems in a fishery result in different levels of social capital in a community, focusing on revenue sharing arrangement and an individual fishing quota. The results suggest that revenue sharing arrangement leads to less conditional cooperation among fishers while no impact is found in unconditional cooperation.

Revenue sharing arrangement, accompanied by collective fishing operation, changes how fishers communicate with other fishers; revenue sharing fishers exchange more varieties of fishing information more frequently.

The negative effect on conditional cooperation is somewhat contrary to the literature on the VCM (Carpenter, Bowles, Gintis, & Hwang, 2009), which suggested that strong reciprocity was a key in team production. The result in this study implies that a key in team production is not necessarily conditional cooperation or reciprocity at least in a context of revenue sharing arrangement in a fishery. The fishers under revenue sharing, who face the same incentive structure as the VCM, are not necessarily conditional cooperators but rather free-riders. Yet, these fishery groups have been successfully maintaining the revenue sharing arrangement for decades. This can suggest two things. First, the other factor may have been contributing to the maintenance of revenue sharing arrangement in these fishery groups. One possible factor is their operational rules that the fishery groups under revenue sharing arrangement self-impose. Every fishery group under revenue sharing arrangement operates together to ensure equal contribution of labor in days and hours among the member fishers. Contrary to anonymity in the VCM, contribution in fishing operation can be easily monitored in terms of landings at the port. Although the fishers have incentives to free-ride, they may still like to compete in fishing, which can counteract free-riding inclinations exhibited in the VCM. Gaspart and Seki (2003) emphasized fishers' nature for competition as an important driver to maintain the revenue sharing arrangement. Anecdotal evidence also exists to support this claim; we heard from a leader fisherman that his fellow fishers still compete for landings even though they

have been under revenue sharing for decades. Second, another possibility is that the estimated coefficient of revenue sharing arrangement may be suffering from endogeneity. If these revenue sharing fishery groups had been particularly struggling with free-riding in collective efforts such as the efforts for the stock enhancement, the groups could have been in a way forced to employ revenue sharing to motivate these collective efforts. If this is the case, the estimate from the model is biased and is not a true effect of revenue sharing on conditional cooperation.

The effect of revenue sharing on information network can be attributable to collective fishing operation as well as revenue sharing arrangement. In daily fishing operation revenue sharing fishers fish together as a group and coordinate their fishing efforts and their stock enhancing activities. This way of operation in fishing requires revenue sharing fishers to communicate more information more frequently because information can help fishers to successfully cooperate in fishing, on which revenue can greatly hinge and fishers are financially bound together by revenue sharing arrangement.

Insignificant estimated coefficients of the size of information network and the density of the network suggest that revenue sharing fishers do not necessarily share information with more people compared with non-revenue sharing fishers although they exchange more varieties of information more frequently. Revenue sharing arrangement can provide disincentive to hold back on sharing sensitive fishing information. For example, sharing information on specific hot-spots can decrease the return from fishing effort at the presence of congestion externality, and thus harvesters

may prefer to keep it private. However, it is in their interest for revenue sharing fishers to share such information to allocate their collective fishing effort most efficiently.

This may also suggest that revenue sharing fishers have different structure of communication that do not necessarily change the size of the network. For example, hierarchical structure or centralized structure is more efficient in conveying information from one edge of a person to the other edge; the length of pass and/or diameter of the network can be different when the number of relationships an individual have is different. Investigation of difference in network structure between different management systems is left for future research.

Formal economic institutions are important; not only they determine economic performance of those who are under them but also they affect social aspects of communities, trust, cooperation, other-regarding preferences, norms, and networks. This paper provides empirical evidence for this claim. Social impact of economic institutions can be particularly important in common-pool resource management because resource users in a community are often forced to rely on informal contracting and good governance can greatly depend on social capital (Bowles & Gintis, 2002). For stakeholders and policy makers in common-pool resource management these results can help to understand the effect of management systems currently in place and possibly help to design a policy that incorporates the social effects of management systems.

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Table 3.1. Summary Statistics of Participants

	<i>N</i>	Mean	Std. Dev.	Min	Max
1 if Revenue sharing, 0 otherwise	79	0.58	0.50	0	1
Age	78	53.24	10.21	26	79
Education (1: Junior high school - 6: Graduate degree)	78	1.73	0.60	1	4
Household size (persons)	77	2.77	1.72	0	6
Shellfish fishing experience (years)	73	23.93	13.87	1	55

Note: Not all participants who participated in the experiment completed all the questions in the survey.

Table 3.2. Participants and FCA Size

FCA	Participants	FCA Members	Percent (%)
Shiraoi	9	75	12
Akkeshi	11	73	15
Kushiro	1	6	17
Bekkai	8	47	17
Hamanaka	16	90	18
Wanchu	7	32	22
Ochiishi	8	24	33
Tobu	3	5	60
Hiroo	9	10	90
Konbumori	6	6	100

Table 3.3. Estimating Cooperation Parameters

Dependent variable: Amount contributed by i in session j at round t	
β_0 : Constant	1,272.57*** (0.00)
β_1 : Total group contribution excluding oneself in the previous round	0.08** (0.01)
Variance of u_j^1 (Random intercept for sessions)	45,915.791 (0.58)
Variance of u_{ij}^2 (Random intercept for individuals)	996,737.9** (0.05)
Variance of u_{ij}^3 (Random slope for individual β_1)	0.007 (0.63)
Observations	666
Log-likelihood	-4,222.41

Notes: P-value in parentheses. Multilevel Tobit Regression.

Table 3.4. Summary Statistics of Cooperation Parameters

	N	Mean	Std. Dev.	Min	Max
Conditional cooperation	78	0.00	0.02	-0.05	0.08
Unconditional cooperation	78	0	844	-1,500	2,495

Note: Eighty subjects participated, two of whom were dropped from the analysis.

Table 3.5. Summary Statistics of Information Network Indices

	N	Mean	Std. Dev.	Min	Max
Network size (persons)	78	10.58	15.03	0	90
Network density (%)	78	31.08	34.50	0	100
Varieties of info (1-6 types)	60	2.05	1.27	1	5
Frequency (1: Everyday - 7: Once in season)	63	2.71	1.93	1	7

Notes: Not all subjects completed all the questions in the survey. The last two rows have a particularly lower response rate because these questions are part of the section that requires personal information.

Table 3.6. Estimated Effects of Revenue Sharing on Social Capital

	Dependent variable:			
	(1) Un- conditional	(2) Conditional		
1 if revenue sharing, 0 otherwise	195.87 (0.36)	-0.01** (0.04) [0.02]		
Control	Yes	Yes		
Observations	71	71		
F statistics	1.636	9.824***		
Root MSE	812.3	0.0234		
	Dependent variable:			
	(3) Network density	(4) Network size	(5) Varieties of info shared	(6) Frequency
1 if revenue sharing, 0 otherwise	0.11 (0.36)	203.98 (0.19)	0.60* (0.07) [0.06]	2.02*** (0.00) [0.00]
Control	Yes	Yes	Yes	Yes
Observations	71	71	55	57
F statistics	2.162	5.184**	19.43***	6.650***
Root MSE	0.333	747.1	1.276	1.696

*** p<0.01, ** p<0.05, * p<0.1

Notes: Clustered s.e. p-value in parentheses and bootstrapped p-value in square brackets. BRL yields consistent results.

Figure 3.1. Setup of the Experiment



Figure 3.2. Contents of Information Shared

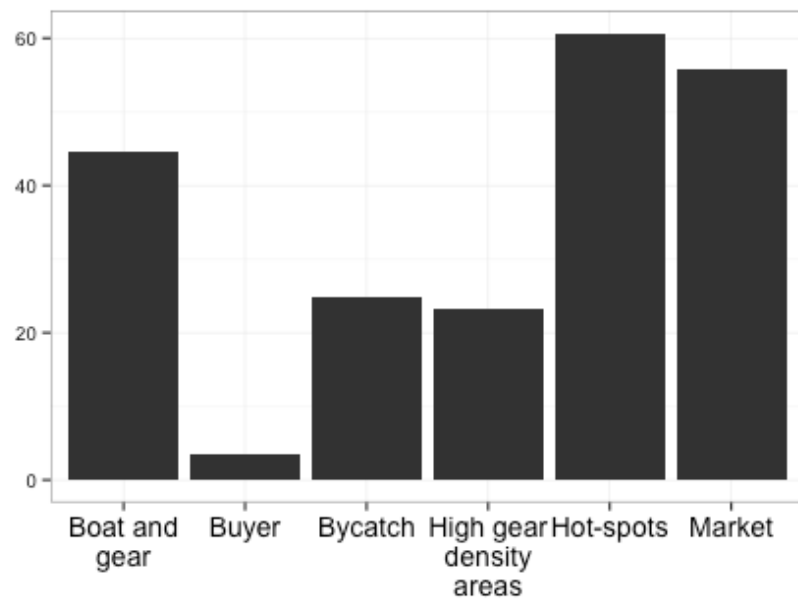
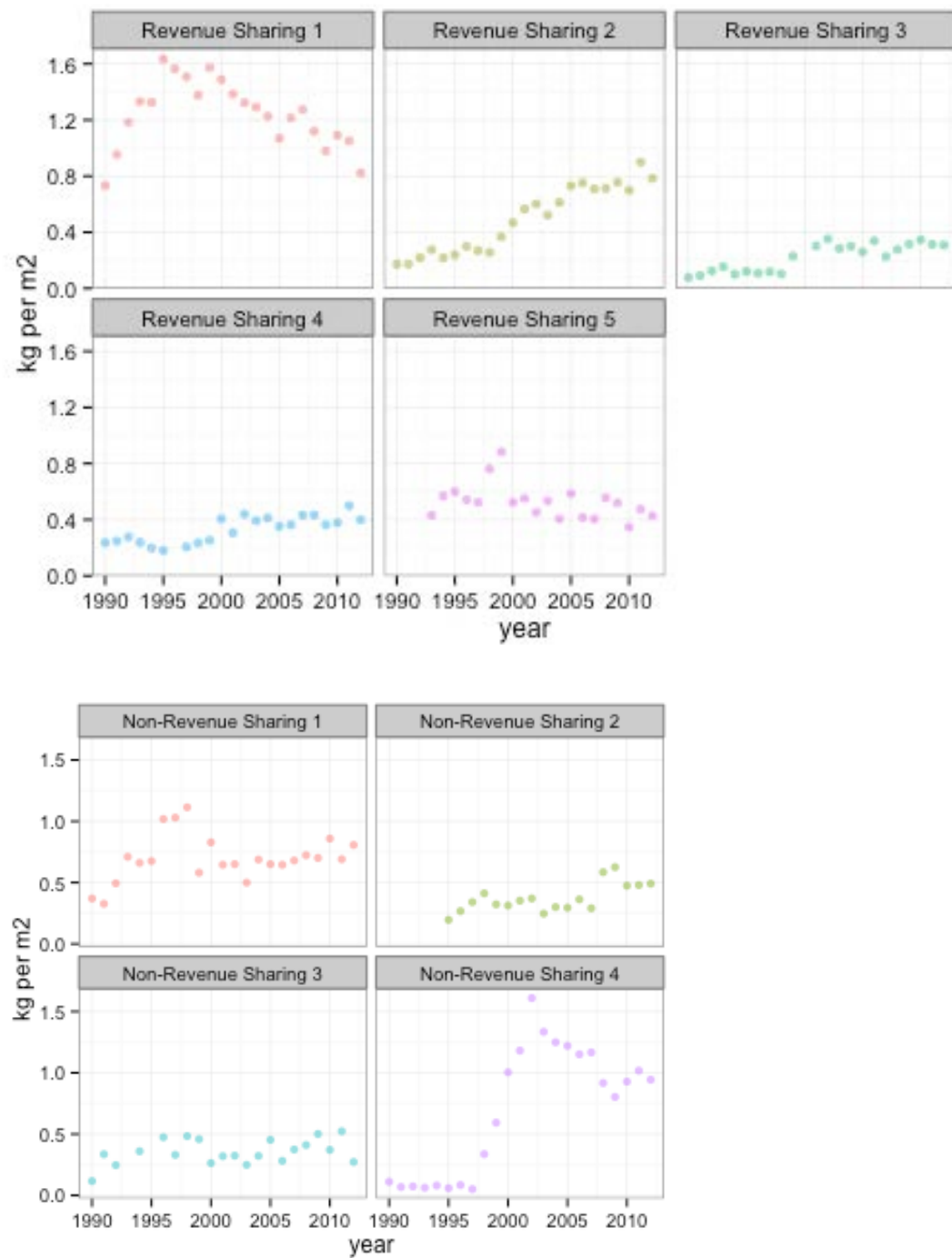


Figure 3.3. Resource Stock Density over Time



CONCLUSION

In this dissertation I investigated how co-management in a fishery can contribute to better management of the resource. The first manuscript examined how efficient management systems to govern common pool resources can evolve endogenously and demonstrated the importance of involving resource users in the governance process, which can ease a political hindrance of the transition of management systems. I examined this in a context of the Rhode Island Fluke Sector Pilot Program using a laboratory experiment. Through successive fishing seasons, the frequency of subjects' choosing the individual quota sector rises from half to over 80 percent of subjects. This suggests that the efficiencies associated with strong individual fishing rights may emerge endogenously from the sectorization process, even without imposing them through regulation. Interestingly, a taste for competition prohibits a complete transition into the individual quota sector.

The second manuscript rigorously measured the direct effects of revenue sharing and social capital in a community-managed fishery in Japan and identified the indirect effects resulting from the interaction between revenue sharing and social capital. An important intermediary between the two factors, revenue sharing arrangement and social capital, and the management outcomes is collective efforts defined as any efforts performed as a group to increase harvesting performance of a fishery. Revenue sharing arrangement and social capital are hypothesized to enhance the effect of the collective efforts, which leads to efficient and sustainable use of resources in the long run. Contribution to the group efforts aligns with self-interest when a group of harvesters shares revenue and harvesters are devoted to collective value due to social

capital in a community. Using the data collected from 79 skippers belonging to ten Japanese fishery groups and wild cluster bootstrap for small sample inference, I find indirect effect of both revenue sharing and social capital interacting to affect the fishery. Revenue sharing arrangement fosters information network in terms of varieties of information shared, which improves the economic outcome perceived by fishers. However, I find no robust evidence of the direct effect of revenue sharing improving an outcome in a fishery. In addition, I find evidence of the long-run positive effect of trust in a community on an economic outcome. The results also show that the fisheries with fishers having similar information network size achieve better stock conditions over time. These results highlight important roles of social capital in improving management outcomes.

The third manuscript provided the quantitative effect of management systems—whether the group has employed revenue sharing or not—on social capital to present insights into an effective policy that can be employed for development of social capital. In particular, this manuscript asks whether a difference in management systems can result in different cooperative relationships and different information networks in a community. Utilizing the same dataset of 79 skippers from ten fishery groups in Japan, I find evidence of the positive effect of revenue sharing on information network possibly because revenue sharing arrangement provides disincentives to compete and accompanies synchronized collective fishing operation. Interestingly, revenue sharing fishers are no more likely to cooperate unconditionally (i.e., unilaterally) and furthermore they are less likely to cooperate conditionally (i.e., only if others cooperate).

The results from the second and third manuscripts emphasize an important role of revenue sharing arrangement in augmenting social capital, particularly information network, which directly improves management outcomes. In other words, although revenue sharing arrangement may not directly improve management outcomes, it can indirectly do so through fostering social capital that has a direct link with the outcomes. Revenue sharing arrangement can be a management tool to improve a fishery, but it can be effective only when it augments social capital among fishers. As a policy intervention, revenue sharing arrangement should be implemented in such a way that it does not decay, rather foster social capital. In the Japanese surf clam fishery examined in the manuscripts all the fishery groups engage in the collective effort for the stock enhancement, which can be best motivated under revenue sharing arrangement. In addition, they collectively operate fishing on a day-to-day base, which can bring intense interactions and enable mutual monitoring among the fishers.

Co-management can help our fisheries achieve better management outcomes. It can facilitate a transition to more efficient management systems to govern resources by involving resource users in the process. Revenue sharing arrangement in a community-managed fishery can encourage social capital, which leads to better outcomes in the fishery. These findings, although specifically embedded in the context of the Rhode Island groundfish fishery and the Japanese surf clam fishery, provide important policy implications to other coastal fisheries with similar traits and more broadly other community-governed natural resource management.

APPENDIX A. Experimental Instrument

The instructions for the experiment of Manuscript 1.

Fishing Game

In this game, we will play 20 rounds (seasons) of a fishing game. At the end of the today's experiment, two of these games will be chosen at random for payment. We do this so that every round or season is independent of the past performance and important to you. Your experimental dollars in those two games will be converted to real dollars.

The Fishery

In today's experiment, you are the owner of a fishing operation that harvests Fish, along with all the other subjects in your group. The fishery in which you will participate is managed for sustainability by a management authority. The authority sets a Total Allowable Catch quota for each season so that the fish stock remains healthy. The total catch of all participants will not be allowed to exceed this Total Allowable Catch quota. The total quota is 36,000 pounds, and 3,000 pounds ($=36,000/12$) are associated with each subject.

How You Make Money

Your task today is to choose how many days to go fishing in each week of the 52-week fishing season. Each day you go fishing, you will land 30 pounds of fish. And each day you go fishing, it costs you 500 experimental dollars per day.

The price you receive for your fish depends on the total pounds of fish landed by all subjects, regardless of which group they are in. Price falls as more fish are landed in each week, according to the table below.

Total Landings per Week	Price per Pound
0	\$50.00
400	\$45.20
800	\$40.40
1200	\$35.60
1600	\$30.80
2000	\$26.00
2400	\$21.20
2800	\$16.40

This fishery is managed under two different systems: Individual Limit Fishing and Group Limit Fishing.

Individual Limit Fishing

Under Individual Limit Fishing, you will be able to harvest up to 3,000 pounds during the season. At 30 pounds a day, this means you can fish up to 100 days. You may fish at any time regardless of how much fish others in your group or in the other group have harvested, but when you reach your quota, you must stop fishing. You do not need to harvest all of your quota. You will not be charged for leaving your quota unused.

Group Limit Fishing

Under Group Limit Fishing, your 3,000 pounds will be added to the total quota of the Group Limit group. For example, if 6 persons are in the group, at 30 pounds a day a person, this means that the group can fish up to 600 days. Each subject in this group may catch as many fish as he or she wants, but once the total quota of the group is harvested by the members, all members of the Group Limit group must stop fishing. The group does not need to catch all of the quota. There is no charge associated with leaving quota unused.

Fishing Software

Attached is an example screen for an Individual Limit Fishing group. The software proceeds through the 52 weeks of each season at a rate of one every 4 seconds.

You choose the number of days you wish to fish by clicking the round dot below the number in the lower left corner of the screen. Your fishing decision automatically carries over from one week to the next, until you change it or the quota is exhausted.

The software will switch you to zero days when the quota limit is reached. In the week the quota runs out, you land your share of the available quota, but are charged for all days chosen, so it is a good idea to reduce your days in that week.

Your Profit

Next to your choice of days is information on the total number of days fished in the fishing group; your landings, price and costs for the current week; and your cumulative profit for the season. The price for the previous week is displayed whether or not you harvested fish, so you can use this information to plan your fishing.

At the top of the screen is a graph that tracks your profit (solid black line), the total quota remaining in your group (solid blue line), and the total quota remaining in the other group (dashed red line).

Your Group

The Your Group box in the center of the screen provides important information on how much other members of your group are fishing, how much fish was landed by your group in the last week, and how much quota remains in your group. You can use this information to plan your fishing.

The Other Group Box

The Other Group box next to the Your Group box allows you to see how members of the other group are using their quota.

The You Box (only for the Individual Limit Fishing group)

The You box will be added in the center of your screen if you choose the Individual Limit Fishing. It provides information about your individual quota. It shows you your quota, your last week's harvest, and the amount of your quota that remains.

Questions

Please think back over these instructions now and make sure the rules are clear to you, and that you understand how to make money.

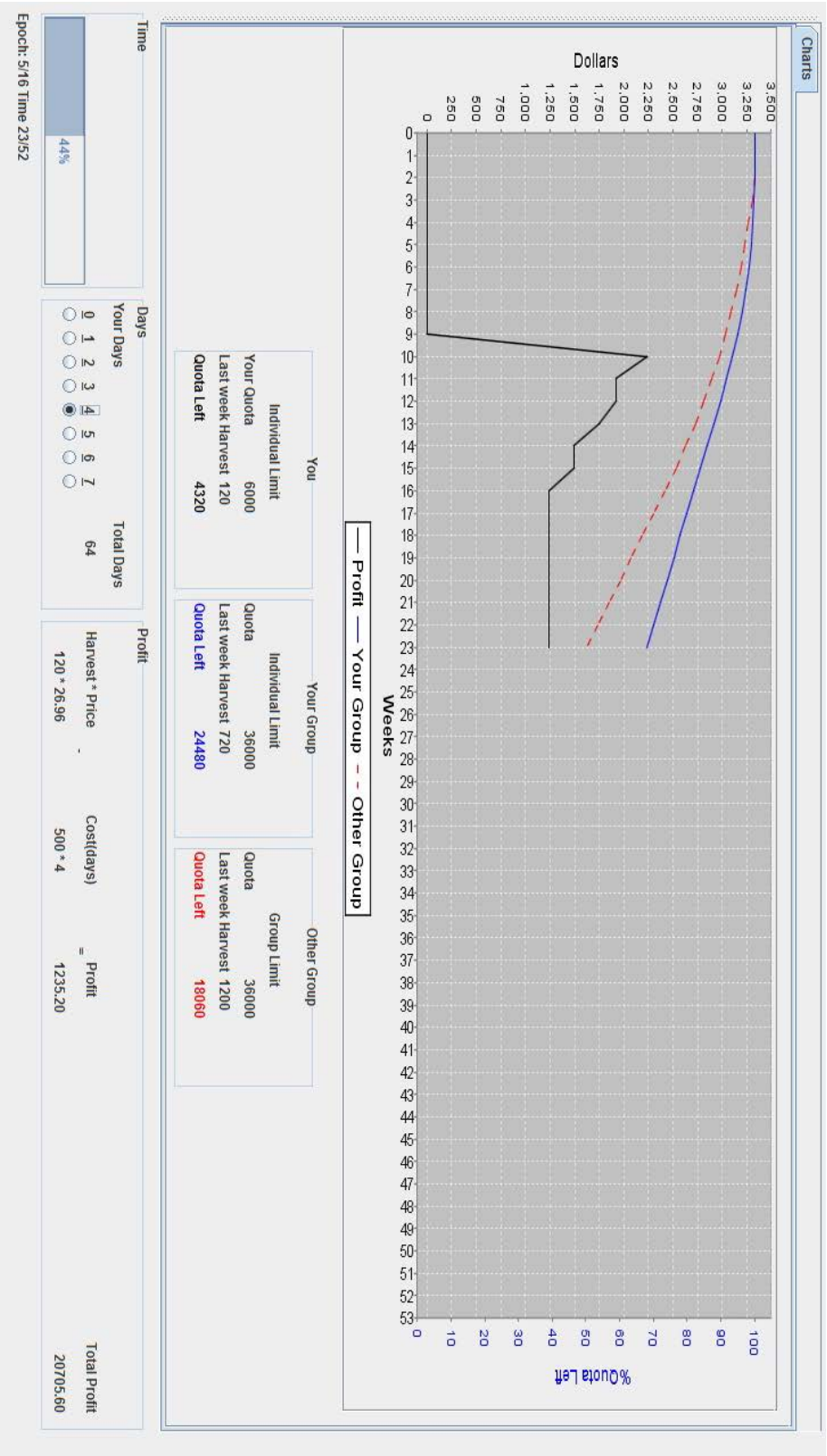
We will now have a practice round for the Group Limit Fishing. There is no practice round for the Individual Limit Fishing. Note that there will be some minor change on the screen. Since everyone fishes in the same fishing group, there will be no information related to the Other Group mentioned earlier.

[Practice round]

Prior to each season, you will be asked to choose whether you would like to fish in the Individual Limit group or the Group Limit group. After all subjects have made their management choices, you can see how many chose to be in each group by dividing its total quota by 3,000.

You will choose your desired fishing group from a drop-down menu that appears at the beginning of each season. You may switch fishing groups between seasons, but you have to stay in the same group throughout the season.

Questions?



The instructions for the experiment of Manuscripts 2 and 3. Original instructions are in Japanese.

Thank you very much for agreeing to participate in the experiment today. During the experiment, you will earn money. How much more money you could make depends on your choices and the choices of others during the experiment. If you follow the instructions and make careful decisions, you could earn more money. Thus, it is important to understand the instructions very well. After the experiment, you will be asked to fill out a confidential survey. You will be paid in cash as you leave.

Before beginning, please find your ID number. This ID number will be used to keep any decisions made at the experiment and the survey confidential.

Please refrain from talking to each other or talking on the cell phone during the experiment and the survey.

If you have any questions or concerns, please feel free to ask any of us.

First, please find the following items in front of you.

- Instructions (this paper)
- Scratch paper
- Calculator
- Pen
- Record sheet

- Three boxes (red, green, yellow each)

Please find your ID number on the sides of the red and green boxes. If you see a different number, please raise your hand.

- Please find five 500 yen coins and five 100 yen coins inside the yellow box. If you see more or less, please raise your hand.

The amount you will earn in the experiment depends on the decisions you and everyone else make during the experiment.

In the experiment, you will be asked to repeat a task ten times.

You are a member of a group of four people. Prior to every round, you will be given an allowance of 3,000 yen. You will be asked to decide how much of the allowance to keep to yourself and how much of the allowance to allocate to a group. Before the experiment, we will notify you privately which group you belong to, but you will not know who belongs to which group.

In the case where the number of participants is not divisible by four, some of you simultaneously belong to two groups, and their decisions are counted in two groups. But only one decision counted in one of the groups is valid for payoff calculation. The decision counted in the other group is only used to make up for lacking members and is irrelevant for their own payoffs. You will not know whether you belong to two groups or whether there are those who belong to two groups in your group. You will only know the results relevant to your actual payoffs.

In the experiment you will be asked to repeat this allocation decision ten times. After the sixth round, we will make some change to the rule. You will play with the same members throughout the experiment.

Steps to complete the allocation decision;

- You are notified privately which group you belong to, either A, B, or C. All of you stay in the same group until the end.
- At the beginning of each round, you are given an empty red box, an empty green box, and a yellow box with five 500 yen coins and five 100 yen coins. Consider this 3,000 yen (five 500 yen coins and five 100 yen coins) as your allowance.
- You are asked to allocate this 3,000 yen either to yourself or to your group. You may allocate any amount from 0 to 3,000 in an increment of 100 yen.
- Please decide privately how much of 3,000 yen to keep to yourself and how much to allocate to your group. Please do not discuss with your neighbors. We will never tell anyone your decisions, and no one will know how much others have allocated to themselves or to their group.
- **Please put the money to keep to yourself in a red box and the money to allocate to your group in a green box. Please transfer all 3,000 yen either to a red box or to a green box.**
- Please write down the amount you have kept to yourself and the amount you have allocated to your group on a record sheet.
- We collect all the boxes and record everyone's decision.
- We distribute a result slip that includes the total amount allocated to your group and dividends from your group earnings. The total amount allocated to your group will be multiplied by two and distributed equally to every member of the group. However, no one will know who have distributed how much to the group.
- Finally, please calculate your total payoffs for this round by adding the amount you have kept to yourself and the dividends from your group, and write it down on a record sheet.
- This completes one round.

Important

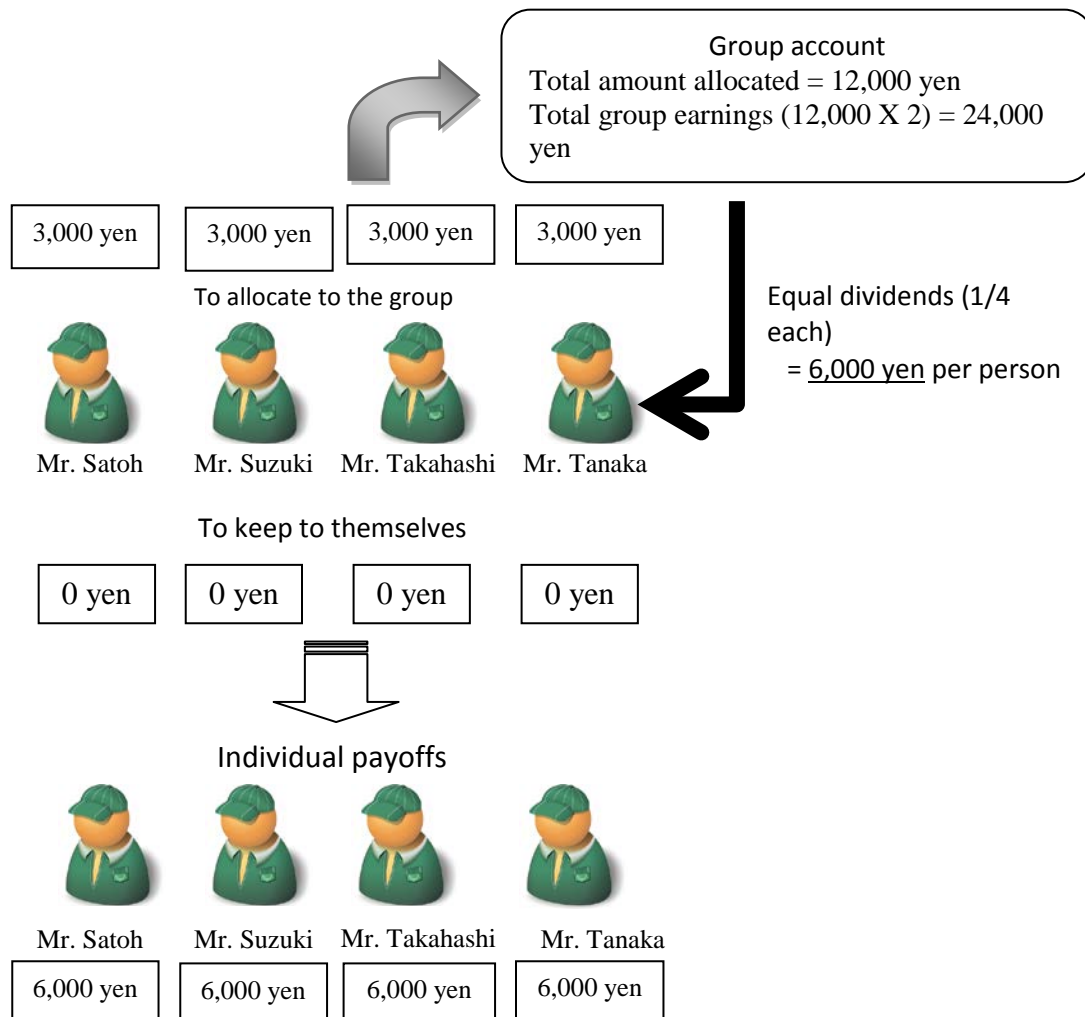
How to calculate your total payoffs

1. The amount you keep to yourself is your own earnings.
2. The total amount allocated to the group by your group members is multiplied by two. Consider this as your group's total earnings. The group's total earnings are distributed equally to every member of the group.

Regardless of how much you have allocated to the group, you receive the same amount of the dividends as the others in your group. Those who have not allocated any money to the group also receive the same amount of the dividends as the others in the group. The sum of the above 1 and 2 is your total individual payoffs for a round.

The following examples will help you understand how this experiment works.

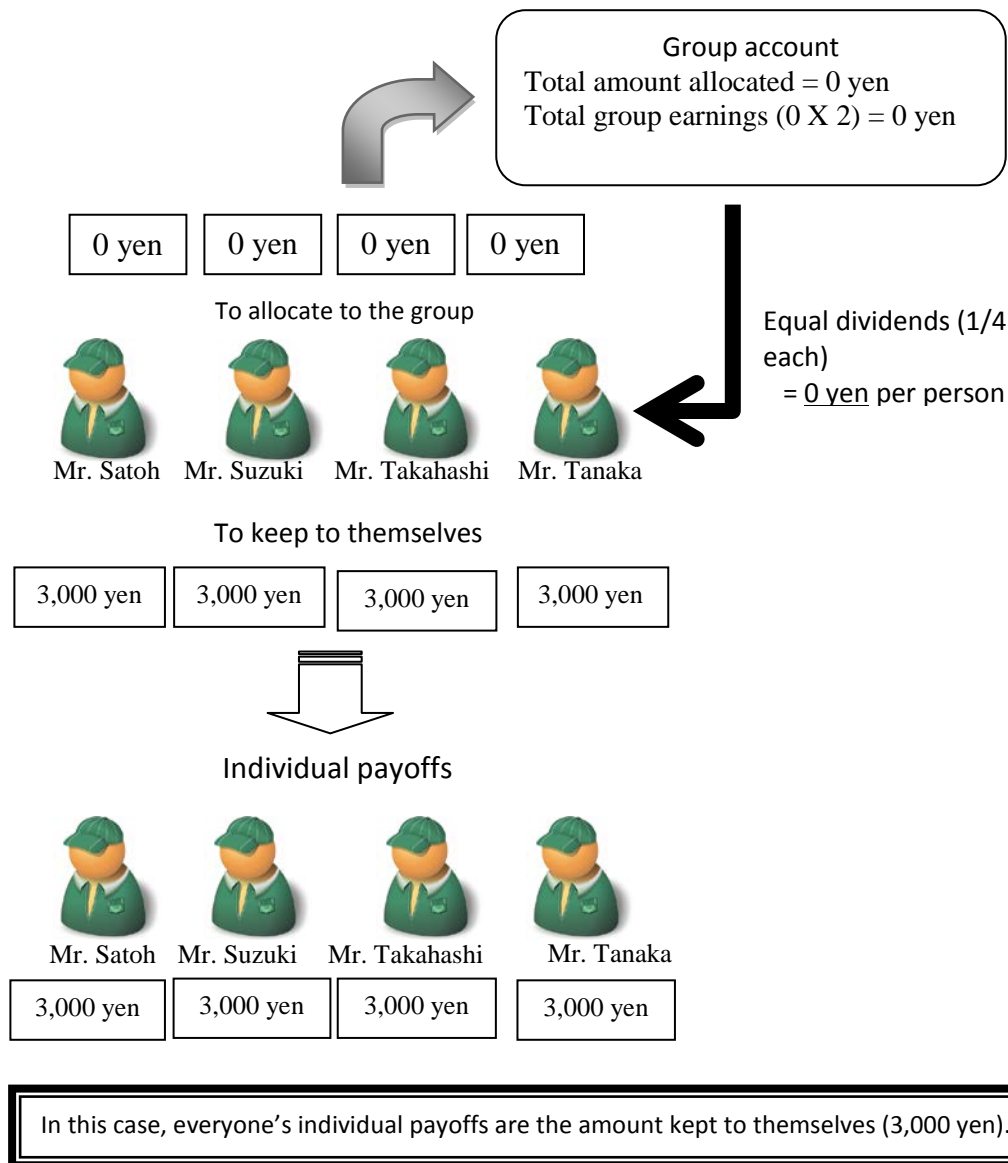
Example 1: When every member allocates all of the allowance to the group



In this case, everyone's individual payoffs are the dividends from the group earnings (6,000 yen).

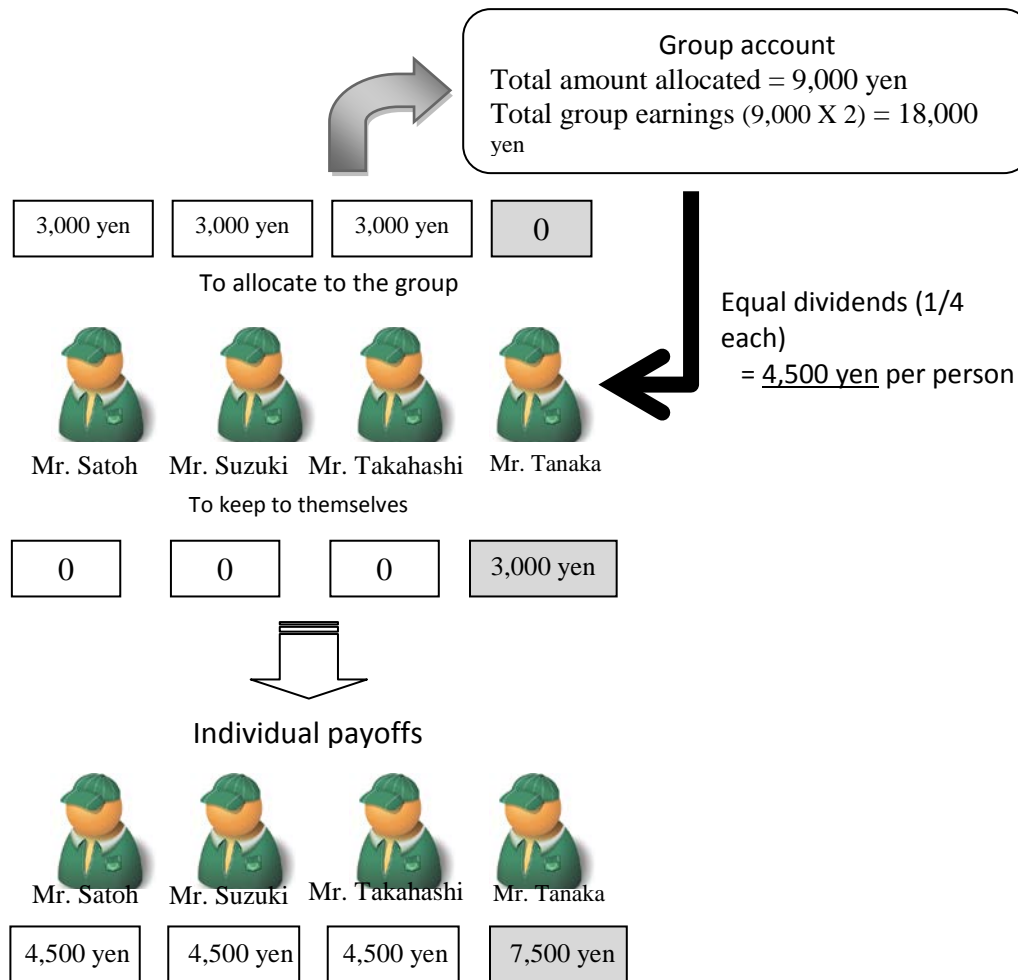
Why? The total amount allocated to the group is $3,000 + 3,000 + 3,000 + 3,000 = 12,000$. The total amount allocated by all the members in the group is 12,000 yen. This 12,000 yen is multiplied by two and then divided by four to be shared equally among all the members. Thus, every member of the group receives 6,000 yen as individual payoffs.

Example 2: When every member keeps all of the allowance to themselves



Why? The total amount allocated to the group is $0 + 0 + 0 + 0 = 0$. The group earnings are zero, and everyone receives 3,000 yen, the amount kept to themselves, as individual payoffs.

Example 3: Three members allocate all of their allowance to the group and the other one member keeps all of his allowance to himself.



In this case, Mr. Satoh's, Mr. Suzuki's, and Mr. Takahashi's individual payoffs are the dividends from the group earnings only (4,500 yen) while Mr. Tanaka's individual payoffs are the sum of the dividends and the money kept to himself (7,500 yen).

Why? One of the four members allocated nothing to the group, and the other three allocated 3,000 yen each to the group. The total amount allocated to the group is $0 + 3,000 + 3,000 + 3,000 = 9,000$. This 9,000 yen is multiplied by two and then shared equally among all the members. Whether one has allocated to the group or not, everyone receives 4,500 yen from the group earnings. Thus, those who allocated 3,000 yen to the group receives 4,500 yen as individual payoffs, but those who allocated nothing to the group receive 3,000 yen, the amount kept to themselves, plus the dividends of 4,500 yen as individual payoffs.

Are there any questions up to this point?

At the end of the experiment, two of the ten rounds will be chosen at random. The average amount of these two rounds will be actually paid. This means that all the rounds have a possibility of deciding how much cash you can earn. It is important you make a careful decision every round.

We are about to begin the first round. Please think back over the instructions now and make sure the rules are clear to you. If you have any questions, please raise your hand.

Part 2 (to be handed out after the 5th round)

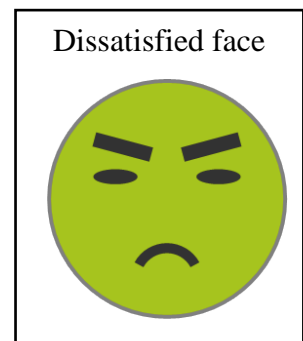
We have completed five rounds, and we modify the rules for the rest of the rounds.

Same steps as before;

- All of you stay in the same group as before until the end.
- At the beginning of each round, you are given an empty red box, an empty green box, and a yellow box with five 500 yen coins and five 100 yen coins.
- Please put the money to keep to yourself in a red box and the money to allocate to the group in a green box. You may allocate any amount from 0 to 3,000 in an increment of 100 yen. Please transfer all 3,000 yen either to a red box or to a green box.
- Please decide privately how much to keep to yourself and how much to allocate to your group.
- Please write down the amount you have kept to yourself and the amount you have allocated to your group on a record sheet.
- We collect all the boxes and record everyone's decision.
- We distribute a result slip that includes the total amount allocated to your group and the dividends from your group earnings. The total amount allocated to your group will be multiplied by two and distributed equally to every member of the group. However, no one will know who have distributed how much to the group.
- Please write down the dividends from your group earnings on the record sheet.

The following steps apply for the following rounds;

- You are asked to fill out an order form for “dissatisfied face.” If you feel dissatisfied with the group allocation from other members in your group, you can send “dissatisfied face” as shown in the box. Whether you want to send “dissatisfied face” or not, please fill out the form by circling the corresponding statement. It costs 60 yen to order “dissatisfied face.”
- If you didn't order “dissatisfied face,” your final payoffs are the sum of the amount kept to yourself and the dividends from your group earnings. If you ordered “dissatisfied face,” your final payoffs are the sum of the amount kept to yourself and the dividends from your group earnings minus 60 yen, the cost of sending “dissatisfied face.” Please write it down on the record sheet.
- We collect the order forms.
- As many “dissatisfied face” slips as ordered by the members in your group are put in a yellow box with coins and returned to you with a red and a green boxes. Note that you also receive “dissatisfied face” you yourself ordered. You will not know who have sent “dissatisfied face.”



Are there any questions before we resume?

APPENDIX B. Survey Instrument

The survey used for Manuscripts 2 and 3. Originals are in Japanese.

This survey asks about your opinions and how you engage in shellfish fishery. It will provide important information as the results in the experiment. We appreciate your cooperation. The ID number will keep your answers in this survey confidential. We will not identify individuals from the answers in this survey.

Please write down your ID number in the space provided.

Q1. This question asks about your opinions. Please indicate how strongly you agree or disagree with the following statements on a five-point scale. Check only one box for each statement.

	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree
a. These days you can't count on strangers	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
b. In dealing with strangers one is better off to be cautious until they have provided evidence that they are trustworthy.	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5

Q2. The following questions ask you about how you share private, sensitive information that influenced your profits from shellfish fishing and/or its catch with other shellfish fishermen.

a. During the 2012 season, how many shellfish fishermen did you share such information with?

 persons

b. How many of the fishermen that you shared such information

with during the 2012 season are also family members?

persons

- c. We would like to ask you for the names of 5 fishermen that you shared most such information with during the 2012 season. Please raise your hand at this point. We will bring a separate sheet for listing their names.
We will convert the names you provide to ID numbers, whether or not the person is participating in the research today. Please provide their full names. After we convert the names into the numbers, we will destroy all the sheets in front of you. They will not be used to refer to the answers in this survey.
- d. Please indicate the number of years you have known each of the fishermen you identified in the above question c.

	Number of years
Fisherman 1	
Fisherman 2	
Fisherman 3	
Fisherman 4	
Fisherman 5	

- e. What do you have in common with each of these fishermen? Check all that apply.

	Family members ₁	Close friends ₂	Boat and gear ₃	Age group ₄	Neighborhood ₅
Fisherman 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- f. On average, how often did you share private, sensitive information that influenced your profits and/or catch with each of these fishermen during the 2012 season? Check only one box for each fisherman.

	Every day	Every few days	Once per week	Once every two weeks	Once per month	Every two months	Once during the season
Fisher man 1	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇
Fisher man 2	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇
Fisher man 3	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇
Fisher man 4	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇
Fisher man 5	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇

g. When sharing such information with these fishermen during the 2012 season, what kind of information did you share? Check all that apply.

	Market ₁	Buyer information ₂	Specific hot-spots ₃	Market for bycatch and its hot-spots ₄	High gear density areas ₅	Boat and gear ₆
Fisherman 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fisherman 5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

h. How influential was the information you received from these fishermen to your profits and/or catch? Check only one box for each fisherman.

	Not influential at all 1	Not influential			Influential			Very influential 8
		2	3	4	5	6	7	
Fisherman 1	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇	<input type="checkbox"/> ₈

Fisherman 2	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇	<input type="checkbox"/> ₈
Fisherman 3	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇	<input type="checkbox"/> ₈
Fisherman 4	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇	<input type="checkbox"/> ₈
Fisherman 5	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅	<input type="checkbox"/> ₆	<input type="checkbox"/> ₇	<input type="checkbox"/> ₈

Q3. The following questions ask you about how you share general, public information that did NOT influence your profits from shellfish fishing and/or its catch with other fishermen.

- a. During the 2012 season, how many shellfish fishermen did you share such information with? persons
- b. When sharing such information with these fishermen during the 2012 season, what kind of information did you share? Check all that apply.

Contents of information	<i>Check all that apply</i>
Market ₁	<input type="checkbox"/>
Buyer information ₂	<input type="checkbox"/>
Specific hot-spots ₃	<input type="checkbox"/>
Market for bycatch and its hot-spots ₄	<input type="checkbox"/>
Boat and gear ₅	<input type="checkbox"/>
Other ₆ (Please specify below)	<input type="checkbox"/>

- c. How often did you share such information with other fishermen during the 2012 season? Check only one box.

Frequency	<i>Check only one box</i>
Every day	<input type="checkbox"/> ₁
Every few days	<input type="checkbox"/> ₂
Once every two weeks	<input type="checkbox"/> ₃
Once per month	<input type="checkbox"/> ₄
Every two months	<input type="checkbox"/> ₅
Once during the season	<input type="checkbox"/> ₆

Q4. This question asks about your opinions. Please indicate how strongly you agree or disagree with the following statements on a five-point scale. Check only one box for each statement.

	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree
a. Shellfish resources you are fishing are currently abundant.	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅
b. Resource management in your FCA is successful in increasing shellfish resources or maintaining certain level.	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅
c. Fishery management in your FCA is successful in increasing fishermen's profits from fishing or maintaining certain level.	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅

Q5. This question asks about how you engage in FCA implementing new rules in shellfish fishing operations.

a. Has your FCA implemented, modified, or discontinued the following operational rules while you are a member?

- Pooling system
- Collective use of fishing boats and/or gears
- Collective branding and/or marketing of catch
- Cooperative fishing (multiple owners jointly operate in one of their boats)
- Collective landing of catch
- Rotation of fishing grounds

	<i>Check only one box</i>	
Yes	<input type="checkbox"/> ₁	→ to Q b.
No	<input type="checkbox"/> ₂	→ to Q c.
Don't know	<input type="checkbox"/> ₃	→ to Q c.

b. Please answer this question if you chose "Yes" to the above question a. What role did you play when FCA was implementing, modifying, or discontinuing the rules? Check all that apply.

Role you played when FCA implemented, modified, or discontinued the rules	<i>Check all that apply</i>
Have proposed the new rule ₁	<input type="checkbox"/>
Have convinced other fishermen for the proposed rule ₂	<input type="checkbox"/>
Have stated own opinion on the proposed rule ₃	<input type="checkbox"/>
Have voted for/against the proposed rule ₄	<input type="checkbox"/>
Other ₅ (Please specify below)	<input type="checkbox"/>

c. Are you currently serving or have you served as an executive member of the shellfish group?

Executive member	<i>Check only one box</i>
------------------	---------------------------

Yes	<input type="checkbox"/> ₁ → to Q d.
No	<input type="checkbox"/> ₂ → to Q6
Don't' know	<input type="checkbox"/> ₃ → to Q6

- d. How many years have you been serving or have served as an executive member?

years

Q6 This question asks about interaction with other shellfish fishermen outside of fishery.

- a. Are there any shellfish fishermen in your neighborhood?

Shellfish fishermen in neighbourhood?	<i>Check only one box</i>	
Yes	<input type="checkbox"/> ₁	→How may fishermen? <div style="border: 2px solid black; width: 80px; height: 30px; display: flex; align-items: center; justify-content: center;"> </div> persons
No	<input type="checkbox"/> ₂	
Don't know (Please explain why.)	<input type="checkbox"/> ₃	

- b. Do you meet other fishermen other than at the port? For example, at party, family gathering, etc.

Interactions outside of the port	<i>Check only one box</i>	
Yes	<input type="checkbox"/> ₁	→ to Q c.
No	<input type="checkbox"/> ₂	→ to Q7
Don't know (Please explain why.)	<input type="checkbox"/> ₃	→ to Q7

- c. On average how often do you meet other fishermen other than at the port? Check only one box.

Frequency of meeting outside of the port	<i>Check only one box</i>
More than once a week	<input type="checkbox"/> ₁
Few times a month	<input type="checkbox"/> ₂
Once every few months	<input type="checkbox"/> ₃
Less than every half year	<input type="checkbox"/> ₄

- d. What are those occasions? Please specify below.

(

Q7 This question asks about experience on shellfish resources.

- a. Have you seen the shellfish resources depleted or drastically decreased? Check only one box.

Shellfish resources	<i>Check only one box</i>
Seen them depleted	<input type="checkbox"/> ₁ → to Q b.
Seen them drastically decreased	<input type="checkbox"/> ₂ → to Q b.
Never seen	<input type="checkbox"/> ₃ → to Q8
Don't know	<input type="checkbox"/> ₄ → to Q8

- b. How many years ago did you see them depleted or drastically decreased? Check all that apply.

How many years ago?	<i>Check all that apply</i>
Recently (now to 5 years ago) ₁	<input type="checkbox"/>
6 years ago to 10 years ago ₂	<input type="checkbox"/>
11 years ago to 15 years ago ₃	<input type="checkbox"/>
16 years ago to 20 years ago ₄	<input type="checkbox"/>

More than 21 years ago ₅

☐

c. How did you respond as an individual to such depletion or decrease in resources?

(

)

d. How did your shellfish group respond to such depletion or decrease in resources?

(

)

Q8 This question asks about you.

a. What is your age?

years

b. What is your gender?

☐ ₁ Male ☐ ₀ Female

c. What is the highest level of education that you have completed?.

- | | |
|--|---|
| <input type="checkbox"/> ₁ Junior high school | <input type="checkbox"/> ₄ 2 year college degree |
| <input type="checkbox"/> ₂ Senior high school | <input type="checkbox"/> ₅ 4 year college degree |
| <input type="checkbox"/> ₃ Technical school or some college | <input type="checkbox"/> ₆ Graduate degree |

d. How many people are there in your household, not including yourself?

persons

e. How many of these people are 18 years old or younger?

persons

f. How long have you been fishing shellfish? Please provide the number of years of experience including this year?

years

g. Please provide the tonnage of your boat for shellfish fishing?

tons

h. Did you fish shellfish in other areas before?

Yes	<input type="checkbox"/> ₁ → to Q i.
No	<input type="checkbox"/> ₀ → to Q j.

i. From what year to what year, did you fish shellfish in other areas? Please provide a specific year.

Taisho era • Showa era • Heisei era •
Western calendar year to year
(Please circle one)

j. Including yourself, how many generations has your family participated in commercial fishing? generations

k. Do you engage in other occupation (including fishing other species)?

Yes	<input type="checkbox"/> ₁ → to Q l.
No	<input type="checkbox"/> ₀ → to Q9

l. If you engage in fishing other species, please provide the names of the species. If you engage in other occupation, please provide the occupation.

Fish other species	<input type="checkbox"/> List the names. (<input type="text"/>)
Other occupation	<input type="checkbox"/> List the occupation. (<input type="text"/>)
Other species and other occupation	<input type="checkbox"/> List both the names of other species and occupation. (<input type="text"/>)

This is the end of the survey. Thank you very much for your cooperation.